PRIME MINISTER´S OFFICE
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Government Foresight Report on Long-term Climate and Energy Policy: Towards a Low-carbon Finland

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Abstract

The foresight report of Prime Minister Matti Vanhanen's second Cabinet reviews the long-term challenges of climate and energy policy from global and national perspectives. In the report, the Government outlines targets and measures marking out the road to a thriving and low-carbon Finland.

The time horizon of the report extends until mid-century and beyond as necessary, covering measures both to mitigate climate change and to adapt to its impacts. Besides energy production, the report discusses energy consumption, transport, the forests and other themes central to climate protection.

In the report, the Government sets its target to actively contribute towards limiting the rise in the global average temperature to two degrees Celsius at most. For this target to be achieved, all key countries will need to be committed to strict emission limits. As part of international cooperation, Finland is committed to reducing its emissions to a sustainable level – by at least 80 per cent from the 1990 level by 2050. To support the above objective, a shift to a virtually zero-emission energy system and passenger road traffic will take place in the long term.

Building a low-carbon society calls for strong and urgent measures at all levels and sectors. Municipalities, enterprises, organisations and private individuals alike are needed in the joint effort to combat climate change. The climate perspective needs to be mainstreamed throughout all decision-making, and current policies and measures need to be strengthened while also adopting new ones.

The preparation of the report included commissioning a number studies on climate and energy policy issues as background material. Stakeholder panels and online discussions provided feedback for the preparation. The background scenarios included in the report are also based on a participatory approach.

Keywords
climate and energy policy, future, the long term, preparation, predicting, climate protection, low-carbon society

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FOREWORD

Foresight reports on issues of crucial importance to the nation's future have been drawn up once per Government term. In its programme, Matti Vanhanen's second Cabinet decided to prepare a foresight report on long-term climate and energy policy.

This foresight report strives to assess the challenges faced by climate and energy policy over the long term. The time span enables a contemplative approach and free deliberation between various alternatives. The report aims to mark out the road to a thriving low-carbon Finland.

To underpin the report, the Government commissioned studies on certain issues of central importance to climate and energy policy. Among other things, these studies investigated prerequisites for the global limitation of climate change, the cost-effectiveness of climate policy, and the mainstreaming of the climate perspective.

Effort has been made to ensure a participatory approach in the preparatory work. Individuals and stakeholders have been encouraged to present their views via Internet questionnaires and discussions, workshops and group panels. Moreover, care has been taken to write the report in a manner that would make it easily approachable for citizens.

A multistage process was applied to draw up four different model scenarios illustrating potential paths towards a low-carbon Finland. The scenarios are not the Government's recommendations; instead, they are examples of different futures, all of which have their own strengths and challenges. It is hoped that the scenarios illustrate the changes required by the low-carbon approach and that they will stimulate public debate on the desired paths to the future.

It pays to read the foresight report in parallel with the other documents outlining the Government's climate and energy policy. The most important of these is the Long-term Climate and Energy Strategy. The principal sectoral documents are:

- In transport policy, the Transport Policy Report, the Climate Policy Programme of the Ministry of Transport and Communications, and the Public Transport Action Plan
- In development policy, the Development Policy Programme
- In public procurement, the Government Resolution on Sustainable Procurement
- In adaptation, the National Adaptation Strategy

In the Climate and Energy Strategy, the Government gave an outline of its policy mainly up to the year 2020. For each sector, the strategy presents goals and concrete measures whereby Finland will meet the EU's climate and energy targets. The foresight report supports and supplements the work carried out as part of the strategy. The report continues its review of policies especially after 2020 and outlines paths towards a sustainable emission level over the long term.

The foresight report is part of the dialogue on the future between the Government and Parliament. The Prime Minister's Office is responsible for coordinating the implementation of the report, but most practical solutions fall within the scope of the relevant ministries.

The introduction to the report defines the goals for the work: To raise Finland to be a leader in climate protection. The second chapter describes the causes and effects of the climate crisis. The third chapter deals with climate policy as a global challenge.

The fourth chapter and Appendix 1 present the path examples devised for the report: towards a low-carbon Finland. In the fifth chapter, climate protection is examined from the wider perspective of sustainable development. The sixth chapter analyses climate policy especially from the viewpoint of businesses, while the seventh chapter focuses on people's daily life.

The eighth chapter presents policies required by adaptation to climate change. The ninth chapter approaches climate policy from the viewpoint of policies and measures. The tenth chapter describes the administrative changes required by a low-carbon society. The report's main policy decisions are summarised in the conclusions.

The appendix following the summary illustrates the scenarios for a low-carbon Finland. The second appendix contains background information: a description of the preparatory process and the bodies that participated in it and a list of background reports. When approving the report, the Government has not discussed these appendices.

The foresight report has been drawn up at the Prime Minister's Office in cooperation with the sectoral ministries. The authors have consulted with a group of experts and over a hundred other specialists and representatives of stakeholders who have participated in various workshops and thematic discussions.

Government Climate Policy Specialist Oras Tynkkynen has been responsible for the preparation of the report in the Prime Minister's Office, and the work has been supervised by a ministerial working group led by Minister of the Environment Paula Lehtomäki (28 September 2007–11 April 2008 Minister of the Environment Kimmo Tiilikainen). The other members of the ministerial working group were Minister of Defence Jyri Häkämies (until 4 April 2008 Minister for Foreign Affairs Ilkka Kanerva), Minister of Finance Jyrki Katainen, Minister of Labour Anni Sinnemäki (until 25 June 2009 Minister of Labour Tarja Cronberg), Minister of Housing Jan Vapaavuori, Minister of Transport Anu Vehviläinen, Minister for Foreign Trade and Development Paavo Väyrynen, and Minister of Culture and Sport Stefan Wallin.

1 INTRODUCTION: FINLAND – A LEADER IN CLIMATE PROTECTION

Humankind is at a crossroads. Growing and increasingly convincing scientific evidence indicates that we are about to enter a climate crisis. In the worst of cases, climate change could even shake the foundations of civilization.

When at a crossroads, we still have a choice. Humankind can continue on the present path where the advancing climate change would cause human suffering, especially in poor countries. Unrestricted warming of the climate would also destroy ecosystems and could lead to possibly irrevocable and disastrous disturbances in the climate system. All of this would have very negative reverberations in Finland as well.

Alternatively, we can choose a different path. On this path, there will be a rapid reduction in global emissions. Human inventiveness and new technology, public policies and measures, and citizens' participation can be harnessed to pave the way towards low-carbon and carbon-free societies.

The foresight report reviews social developments from the viewpoint of the climate challenge. The further into the future we look, the more uncertainty factors we encounter. The goal of the report is to stimulate discussion about climate change, how to mitigate it and how to adapt to it. The report identifies and outlines policy sectors that need attention in the near future so that tangible changes can be achieved in the long term.

The foresight report was drafted at a time when rapid economic growth was replaced by a global recession. However, the financial crisis has not made climate protection any less urgent or less necessary. On the contrary, only by averting the climate crisis is it possible to avoid a future with many times worse financial crises triggered by climate change.

The Government emphasises that the financial recession is not an acceptable reason to put off emission reductions. Quite the contrary: joint solutions can be sought for simultaneous crises. Renovation of buildings to make them more energy-efficient, investments in renewable energy, and inputs into rail traffic are but a few examples of measures that can simultaneously cut emissions, revive the economy and achieve positive structural changes for the future.

Averting the climate crisis is not free. However, costs can be kept reasonable if policies are sensibly planned.

Climate protection also offers major opportunities. Improving energy and material effectiveness raises competitiveness, new technology and bioeconomy offer opportunities for exports, and indigenous, renewable energy creates jobs. By cutting emissions we reduce our dependence on increasingly expensive imported energy. At the same time, many climate protection measures also help reduce other risks to the environment and health.

No country can solve climate change on its own. Everyone is needed in the global climate effort. Fortunately the number of countries that have set emission targets and drawn up national climate strategies is rising.

Even a small country can play a role by setting a good example, by applying environmentally friendly solutions in practice and by developing sustainable technology. On the other hand, it would be impossible to persuade emerging economies to accept emission reductions if even the world's most affluent countries were not willing to do their share.

Finland has all the prerequisites for becoming a leader in climate protection. In international comparison, Finland is an affluent country with a high level of know-how. We have considerable renewable natural resources and first-rate expertise in sustainable technology. Both public opinion and political leaders in Finland staunchly support climate protection.

Being a leader in climate protection will improve Finland's international status and bring benefits on the expanding market for low-carbon technology. In the end, it is a question of a global moral choice extending over generations.

In this foresight report, the Government presents visions and marks out a road towards a low-carbon Finland. In a low-carbon society, well-being is produced with only a fraction of the current emissions. Finland's emissions have been cut to a level that supports limiting global climate change to a tolerable level and enables adaptation to it. A low-carbon society may only be a beginning – the shift to a totally carbon-free or carbon-neutral society may be ahead during the second half of this century.

The path to a low-carbon society requires major political decisions. Extensive, deep and urgent measures are needed at all levels and sectors of society in order to reduce emissions. Everyone must contribute to the climate effort. Municipalities, enterprises and private individuals are all needed.

On the other hand, the foresight report shows that a low-carbon Finland is possible. Even though many things need to change, many other things would still look very familiar. People will drive cars in Finland in 2050, too – perhaps less than now, and powered by electricity instead of petrol or diesel. Industry will still create jobs, but emissions from industry must be radically lower. People will not be freezing in their homes, but less heat will be wasted and heat will be produced without carbon emissions.

A low-carbon Finland is not only possible; in many respects, things may be better than today. Goods and services can be produced sustainably and efficiently. Cutting atmospheric emissions will have many other environmental and health benefits at the same time. The need to reduce emissions may be a good opportunity to reassess priorities. Perhaps more value will be given to things that have been overshadowed by a material standard of living: social relations; free time; culture; and caring about one another.

The foresight report investigates the outlook for climate and energy policy up to the middle of this century and beyond. When sights are set so far, the most certain conclusion is that many things will change markedly. In 1968 hardly anyone could have imagined the collapse of the Soviet Union, the existence of the Internet, the rise of China, or the popularity of mobile phones. Similarly, by 2050 many things will change in ways that we cannot foresee now.

Climate change is a challenge to policy both because of its exceptional time span and because of its scope. The climate perspective must be integrated into all decision-making and all policies. The shift to a low-carbon society calls for consensus extending over government terms and party lines.

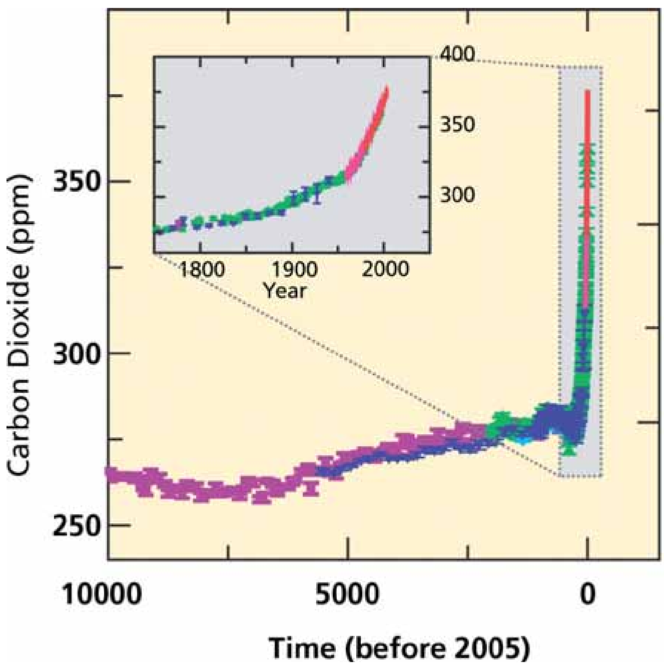
The foresight report is one instrument for creating that long-range consensus.

2 WHAT IS REQUIRED TO AVERT A CLIMATE CRISIS?

Climate change threatens to cause significant damage to people and the environment. At their worst, the effects may be irrevocable and disastrous. Keeping global warming tolerable, within at most two degrees Celsius, requires radical global emission reductions. Cutting emissions to a sustainable level may still be possible, but time is running out.

Since the Industrial Revolution, humankind has been changing the composition of the atmosphere decisively by burning fossil fuels that had accumulated for millions of years. The atmospheric concentration of the principal greenhouse gas produced by humans, carbon dioxide, has risen by more than one third and has reached a clearly higher level than ever before during the past 650,000 or possibly even 20 million years.

Figure 2.1 Variations of atmospheric carbon dioxide concentrations



Variation of carbon dioxide concentrations in the atmosphere during the past 10,000 (large panel) and 250 (inset panel) years. Measurements are shown from ice cores (symbols with different colours for different studies) and atmospheric samples (red lines).

Source: IPCC. 2007. IPCC Fourth Assessment Report. Working Group I Report ”The Physical Science Basis. Summary for Policy Makers”. p. 3.

The climate also changes for natural reasons. However, the rising atmospheric concentrations of greenhouse gases have reinforced the natural greenhouse gas effect; in consequence, the mean temperature of Earth has already risen by about 0.8° C when compared against pre-industrial times. This phenomenon, mostly caused by humans, is called climate change.

Warming is not distributed evenly. In Arctic regions, temperatures have risen nearly twice as much as the average on Earth. Similarly, warming on land has been twice as rapid as in sea areas. Warming does not necessarily proceed steadily over time, either. At times, it may slow down and then accelerate again.

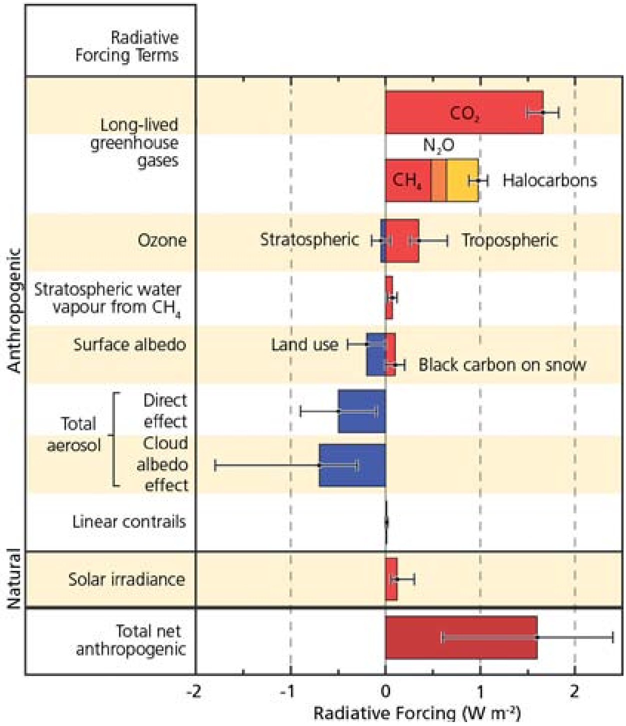
The warming that has taken place so far has already caused numerous changes in the environment. These include:

- Cold periods have decreased and hot periods increased
- The mass of glaciers, the ice cover in northern polar regions and permafrost have shrunk
- The sea level has been rising
- The distribution of precipitation, evaporation and winds has changed
- Periods of droughts have become more severe and longer and rainstorms have become more common
- Seeking a cooler climate, species have moved closer to the poles and to higher altitudes

However, changes have not been discovered in all climatic factors, and not all changes observed are caused by people. For instance, it seems that the Antarctic sea ice has not shrunk, and there are conflicting views about the links between climate change and the frequency of tropical cyclones.

Apart from human action, the climate is also affected by natural factors, such as changes in the intensity of solar irradiance, volcanic eruptions, and the seasonal variation known as ENSO (El Niño Southern Oscillation) in the southern hemisphere. It has been estimated that the impact of anthropogenic factors on global warming is over ten times greater than the impact of changes in solar irradiance. No known theory can convincingly explain the changes discovered without human contribution.

Figure 2.2 Factors affecting the climate



Column width indicates the best estimate of the amount of radiative forcing, while the line bar represents the range of uncertainty.

Based on IPCC. 2007. IPCC Fourth Assessment Report. Working Group I Report "The Physical Science Basis. Summary for Policy Makers". p. 4.

Box 2.1 The IPCC process

The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 to collate scientific information on the climate in order to support decision-making. The IPCC itself does not conduct any research and does not give recommendations on policy.

The main activity of the IPCC is to provide comprehensive assessment reports; the latest of these is the Fourth Assessment Report (AR4) published in 2007. At the outset of the process, the member countries and various organisations propose authors of the report. Experts are not bound to the views of the countries that have put forward their names.

The lead authors are responsible for writing the first draft report. The draft is based on peer-reviewed research, and it is reviewed by independent experts. Over 2,500 experts contributed to the review of the AR4. The review comments and the lead authors' answers to them were published on the Internet. Responsibility for the main body of the text rests with scientific experts, who also have the right to veto any Summaries for Policymakers that are incompatible with the full report.

Climate change affects the lives of billions of people

Climate change is not only an environmental problem, but an issue having major economic, social, political and also security dimensions. Even though some of the impacts – especially in the short term and in some parts of the world – may be positive, most impacts are somewhat negative or very negative, some even potentially catastrophic.

Among other things, climate change is predicted to:

- expand areas suffering from drought and weaken the availability of water
- increase rainstorms and the risk of floods
- damage ecosystems and expose a significant number of species to extinction
- reduce the availability of food and aggravate hunger
- increase diseases and mortality

Climate change may have dramatic impacts on the lives of huge numbers of people. For instance, a rise of two degrees Celsius in temperature may expose an additional one to two billion people to water stress. In Africa alone, climate change may aggravate water stress among 75–250 million people by 2020, and 75 million hectares of land may become unsuitable for rain-based agriculture by the year 2080.

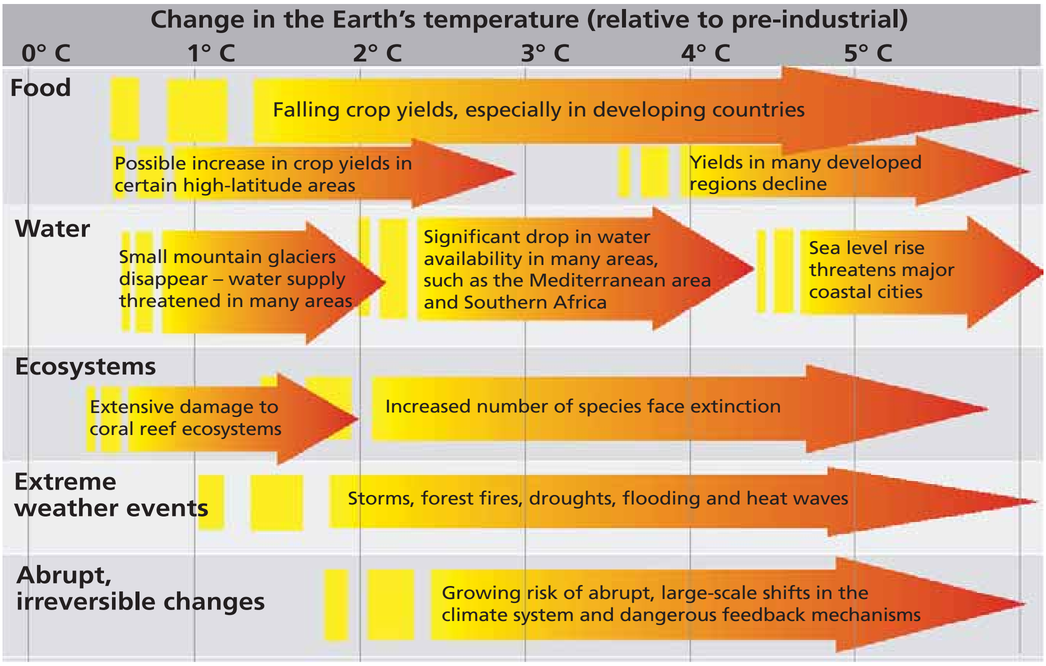
Global warming increases poverty and inequality. The UN Development Programme (UNDP) estimates that climate change threatens to stop development and even wipe out the results achieved during past generations in the eradication of poverty, health care, nutrition and education.

Setbacks in development may increase instability especially in poor and vulnerable countries; in the worst of cases, this may lead to failed states. According to one estimate, as many as 200 million people may have to leave their homes permanently because of rising sea levels, floods and periods of drought. The UN Environment Programme (UNEP) has estimated that the Darfur conflict is already closely linked with desertification and soil degradation, which in turn are associated with regional climate change.

The adverse effects of climate change may also prove to be expensive. The Stern Review commissioned by the British Government estimates that the costs of unmitigated global warming may rise to 5–11 per cent of the world economy, when both monetary and non-monetary hazards are included. Inclusion of the risks of feedback mechanisms could raise the costs to 7–14 per cent, and weighting of the adverse effects borne by the poorest to as much as 20 per cent.

The warmer the climate becomes, the more serious the effects become. There is also major variation among regions. A rise of a few degrees Celsius is estimated to increase crop yields at high and middle latitudes, while decreasing them in the tropics. Intense warming would mean a downturn in the total volume of global food production.

Figure 2.3 Estimated impacts of climate change at various levels of warming



Based on Stern, Nicholas. 2006. Stern Review on the Economics Of Climate Change. Executive Summary, p. 5.

The severity of the impacts is also largely dependent on the adaptive capacity of societies. Developed communities that have anticipated the changes are in the best position; the situation is considerably worse for poor and unprepared countries.

Box 2.2 Assessment of climatology

The scientific view of the climate system and of anthropogenic changes therein is based on research findings accumulated for decades. These findings have been evaluated and tested within the scientific community. Knowledge of climate change has become considerably more accurate and more solid over time.

The findings of climatology are occasionally questioned in public debate. Critics of mainstream climatology – often termed as climate sceptics – claim that the climate is not changing; even if the climate is changing, it is because of natural factors; if people change the climate, their role is minor or the change is slight; or even if people did change the climate significantly, the adverse effects of global warming would be minor or the measures to prevent them would become unreasonably expensive.

Critical evaluation of all findings and unprejudiced review of alternative explanations are part of the normal scientific process. The scientific community has weighed arguments presented, for instance, on changes in sunspots and cloudiness, measurement errors, and shortcomings in models. Based on this evaluation, mainstream science gives the message: people change the climate, and the impacts of climate change may be very severe. During the coming decades, developments in climatology must be followed closely so that the correctness of policy measures can be ensured.

Surprises in store?

The climate system includes feedback mechanisms that may accelerate or decelerate warming. The most important of these are:

- Increases in the amount of water vapour in the atmosphere and changes in cloudiness
- A lower albedo on land and water when ice and snow melt
- Release of methane from under permafrost or from seabed layers
- Vegetation or seas change from carbon sinks to carbon sources

The net effect of the feedback mechanisms speeds up warming. However, some of the mechanisms are still inadequately known, and it has not been possible to take them fully into account in climate models.

The Fourth Assessment Report of the IPCC still assumed that the ice sheet in Greenland and the West Antarctic Ice Sheet would continue to melt at the same rate as before. This might have kept the rise in sea level during the present century at 18–59 centimetres. However, recent studies have indicated that polar glaciers are losing mass at an accelerating pace. According to new estimates, the sea level would rise by about one metre already during the current century.

Warming may also trigger non-linear and extreme changes, which may proceed abruptly once they have exceeded a certain threshold. For instance, the ice sheet in Greenland may melt completely within a few centuries if the global average temperature rises by a mere 1–2° C from the present; the same may happen to the West Antarctic Ice Sheet if the rise in temperature is 3–5° C. The melting of the ice on Greenland and the West Antarctic Ice Sheet would raise the sea level globally by about seven and five meters, respectively. A warming of three degrees Celsius could lead to widespread collapse of the Amazon rainforest and Boreal forests within half a century.

Even though the probability of some extreme changes is rather low or very low, the impacts, if realised, could be very dramatic. The threats should therefore be taken seriously. Apart from reducing the adverse effects of warming, the goal of climate policy should be to minimise the risk of extreme, irrevocable and possibly catastrophic changes.

Box 2.3 What will happen to the Gulf Stream?

The Gulf Stream makes the climate in Northern Europe considerably milder. The advancing climate change has raised the question whether the Gulf Stream could slow down, turn, or stop altogether.

On the basis of the new models, it seems very likely that the Atlantic meridional overturning circulation – including the Gulf Stream – is getting weaker. At most, the intensity of the stream could even be halved. Despite the slowing of the stream, it is predicted that temperatures will rise slightly in the Northern Atlantic as well, because climate change has such a strong warming effect. In contrast, it is very unlikely that there would be any abrupt and strong changes in the circulation during this century.

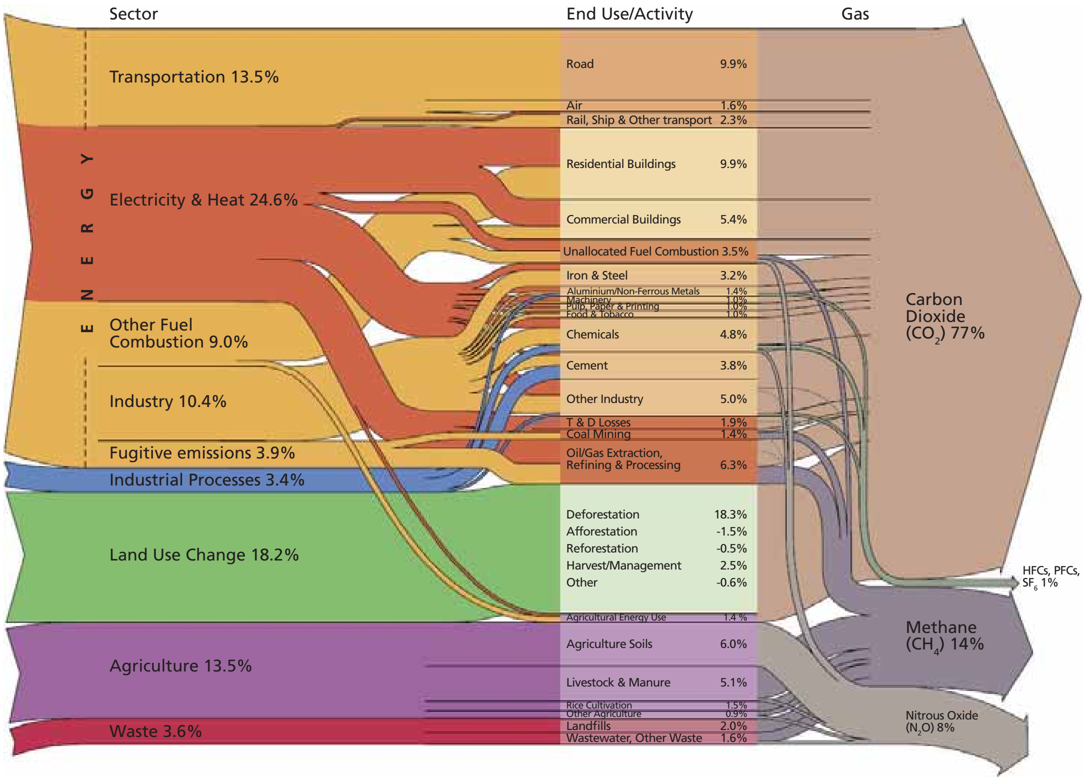
If the circulation were to come to a complete halt for one reason or another, the impacts would be dramatic:
- In some areas of the Northern Atlantic, the sea level would rise rapidly by as much as one metre; in the southern hemisphere, the sea level would sink correspondingly
- In Southern Europe, water runoff would decrease and less water would be available
- In Western Europe, floods caused by melting snow would become more frequent
- Crops would decline
- Changes would occur in the ecosystems of Western Europe and the Mediterranean region

Where do emissions come from?

Humankind produces greenhouse gases by burning fossil fuels, by degrading forests and deforestation, and by using nitrogen fertilisers in agriculture. In addition, emissions arise from industrial processes, livestock production, rice cultivation, and waste decomposition.

The processes where forests, soil and seas absorb carbon dioxide from the atmosphere are called carbon sinks. Natural sinks have so far absorbed much of the emissions caused by human activity; this has clearly slowed warming. Human activity affects the sinks: deforestation, erosion and tilling reduce the capacity of sinks, whereas sustainable forest management can raise their capacity. In the future, global warming may also weaken the capacity of ecosystems to absorb carbon.

Figure 2.4 Global greenhouse gas emissions



Global greenhouse gas emissions in 2000 by sector, end use and gas (excluding CFC compounds).

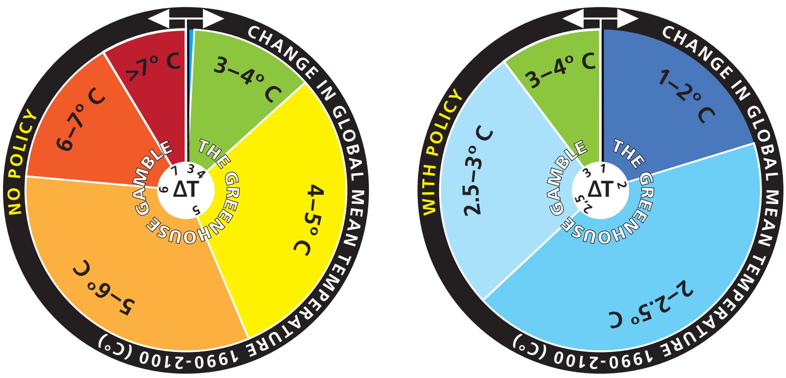
Source: Baumert, K. A. et al. 2005. Navigating the Numbers – Greenhouse Gas Data and International Climate Policy. World Resources Institute.

Atmospheric emissions have increased constantly since the Second World War, with the exception of a brief decline during the oil crisis of the 1970s. During this decade, the pace kept accelerating further until the onset of the recent recession. The reasons underlying this acceleration are rapid economic growth, more carbon-intensive economy, and a reduction in the capacity of sinks to absorb carbon dioxide. With its rapid industrialisation, China has accounted for more than half of the growth in emissions in the 2000s.

Estimates of future emission trends depend on what assumptions are made with regard to population growth, economic growth, technological development, and climate policy. The Intergovernmental Panel on Climate Change (IPCC) estimates that by 2030, global emissions may increase by as much as 90 per cent from the level in 2000. The scenarios do not assume any actual implementation of a climate policy. On low-emission paths, however, other measures are taken to tackle environmental problems.

According to the IPCC, emissions may still lead to an increase of 1.1–6.4° C in the global average temperature by the end of this century. Even the lower figure would be nearly two and the higher figure about seven degrees above the average temperature in pre-industrial times. In comparison: during the peak period of the latest ice age, the average temperature was 3–5° C lower than now. According to a recent estimate published by the Massachusetts Institute of Technology, it is highly likely that warming would be as much as 3.5–7.4° C unless emissions are restricted.

Figure 2.5 Anticipated warming in this century, without climate policy (left) and with climate policy (right)



Researchers at MIT have compiled two climate roulette wheels to illustrate the probability of different degrees of global warming. The sectors of the roulette wheel on the left show the probabilities that the climate will get warmer by certain amounts during the next 100 years without climate policy. The roulette wheel on the right shows the corresponding values when vigorous climate policies are enacted.

Source: Figure published with permission of the Joint Program on the Science and Policy of Global Change of MIT (http://globalchange.mit.edu/). Technical data Sokolov et al. 2009. Probabilistic forecast for 21st century climate based on uncertainties in emissions (without policy) and climate parameters. Journal of Climate, Oct 2009, Vol. 22, Issue 19, s. 5175–5204. American Meteorological Society.

As the climate reacts to greenhouse gases after a time lag, warming will continue even after the atmospheric concentrations of greenhouse gases have levelled out. Other factors would follow; owing to the thermal expansion of water and the melting of glaciers, the rise in sea level would still continue for centuries, even for millennia, after the average temperature levels out. Thus, the climate policy decisions that will be made in the coming years will have implications long into the future.

Human activity also warms the climate indirectly. Examples of this include the condensation trails of aircraft and soot particles from incomplete combustion (black carbon). On the other hand, it is estimated that changes in the albedo of Earth's surface will have an overall cooling effect.

Two degrees as the risk limit

The target set by the European Union is to limit the rise in the global average temperature to at most two degrees Celsius when compared against pre-industrial times. This target is also supported by the Major Economies Forum, whose members include the United States, Japan, China and India.

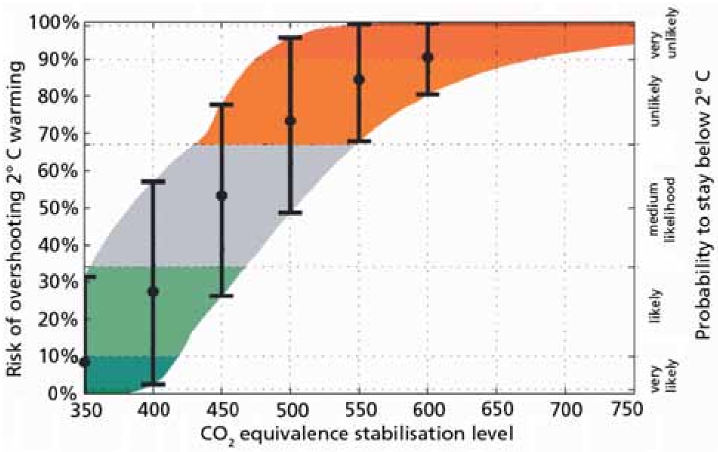
Global warming by two degrees can be regarded as the most realistic target politically; it might still keep the adverse effects of climate change at a tolerable level. Even so, it is no safe level as concerns climate warming.

Warming by no more than 1.5–2.0° C may already mean greater risk of extinctions, marked reductions in crops in some African countries, aggravated water stress for hundreds of millions of people, and the shrinking of glaciers in the Himalayas and on the Tibetan Plateau by as much as four fifths. To minimise risks, it would be justified to try to keep warming at less than two degrees. In fact, the group of the least developed countries and small island states have demanded in climate negotiations that warming should be restricted to at most 1.5° C.

It is still possible to restrict the rise in the global average temperature to two degrees if the climate system does not react to emissions particularly strongly, i.e. climate sensitivity does not prove to be too great. The IPCC has estimated that it would still be possible to remain within two degrees if the carbon dioxide concentration in the atmosphere can be stabilised at 350–400 ppm, at most.

However, setting the concentration target is not only a scientific issue; it is, to a great extent, also a political and moral issue. The target level depends essentially on the probability we are ready to accept in exceeding the risk limit of global warming. The higher the concentration target selected is, the more likely it is that warming will exceed two degrees.

Figure 2.6 The probability of attaining the two-degree target at various concentration levels



Source: Meinshausen, M. 2005. On the risk of overshooting 2° C. Paper presented at Scientific Symposium "Avoiding Dangerous Climate Change", MetOffice, Exeter, 1–3 February 2005.

Concentration targets in line with the two-degree limit require very rapid and radical emission reductions. According to the IPCC, global emissions should peak, at the latest, in 2015. By mid-century, emissions should be cut by at least 50–85 per cent from the level in 2000.

There is little time to reverse the trend, and effective measures are needed at once. Every year without global measures to reduce emissions can lead to a rise of 5 ppm CO_2 equivalent in the peak level of greenhouse gas concentrations. If there is a ten-year delay before measures are taken, reaching the two-degree target could become virtually impossible.

Emission reductions, however, would not end in 2050. During the second half of the century, global net emissions should in practice be cut to zero. In the more distant future, it is likely that even negative emissions would be needed. In other words, greenhouse gases already emitted should be removed from the atmosphere.

The feasibility of very radical global emission reductions has not yet been studied much. However, on the basis of scenario work conducted by various bodies, it seems that it would be technically and economically possible to cut emissions by 50–85 per cent using the currently known and foreseeable technology. Technical possibilities exist even for greater cuts, but the costs then might be unreasonably high.

Even though the rapid reduction of emissions is undeniably challenging, some current trends make the job easier. For instance, depletion of oil and gas reserves that can be exploited at low cost will raise the prices of fossil fuels; this encourages more efficient energy use and improves the competitiveness of renewable energy sources. At the same time, advancements in sustainable technology will lower the costs of emission reductions.

Box 2.4 Plan B: What if climate change gets out of hand?

Some researchers consider it possible that climate change is about to exceed – or may already have exceeded – the threshold after which feedback mechanisms begin to intensify warming uncontrollably. Then the circle of warming could not be stopped even if emissions were cut to zero.

Even in this scenario, the speed of climate change could be slowed first by reducing global emissions as much as possible and then by moving on to negative emissions. This could succeed, for instance, through afforestation, by capturing the carbon dioxide generated in the production of bioenergy, and by binding carbon to charcoal. It may also be necessary to develop technical means to remove carbon dioxide from the atmosphere.

Another idea that has been proposed for consideration is to cool the climate by altering the albedo of Earth. Possible means could be, for instance, artificial expansion of the snow and ice cover, giving preference to tree species that reflect sunlight more, and making the surfaces of buildings lighter.

Artificial altering of the climate involves substantial risks. Very little information is available about the efficacy, cost-effectiveness and sustainability of such measures. More research is needed in this field.

The Government's policies

- Climate change is clearly among the greatest threats to the wellbeing of humankind in this century. The severity and urgency of the threat must be reflected in the policy aimed at averting the threat.
- Finland is committed to doing its own fair share of emission reductions so that, with sufficient probability, warming can be kept within at most two degrees. Finland supports the process to halt the growth of global emissions by 2015 and to cut them clearly by more than half by 2050 when compared against the level in 2000.
- Emission targets are set not only to prevent the adverse effects of warming but also to minimise the risk of extreme, irrevocable and possibly catastrophic changes. Targets are revised whenever necessary as more scientific information is accumulated.
- A multidisciplinary group of experts is appointed to assess developments in climate science, climate technology and climate policy. The group reports to the Government and gives recommendations to support the Government's decision-making.
- More research is conducted on extreme and abrupt climate changes and on feedback mechanisms in the climate system. The means of reducing atmospheric concentrations of greenhouse gases and cooling the climate sustainably and safely are assessed.

3 CLIMATE PROTECTION – A CHALLENGE FOR GLOBAL POLICY

Industrialised nations bear the main responsibility for global warming thus far, but climate change cannot be controlled without major emission restrictions in developing countries as well. Future climate conventions must be as comprehensive and effective as possible. International burden sharing needs solutions that are fair to all countries. The climate perspective must be reinforced in foreign policy, and sufficient funding must be ensured for the transfer of sustainable technology, for halting deforestation, and for adapting to the problems caused by warming in poor countries.

The whole world shares the same climate. Greenhouse gases warm the climate equally much irrespective of where they are emitted. However, the responsibility for causing climate change varies considerably between and within countries.

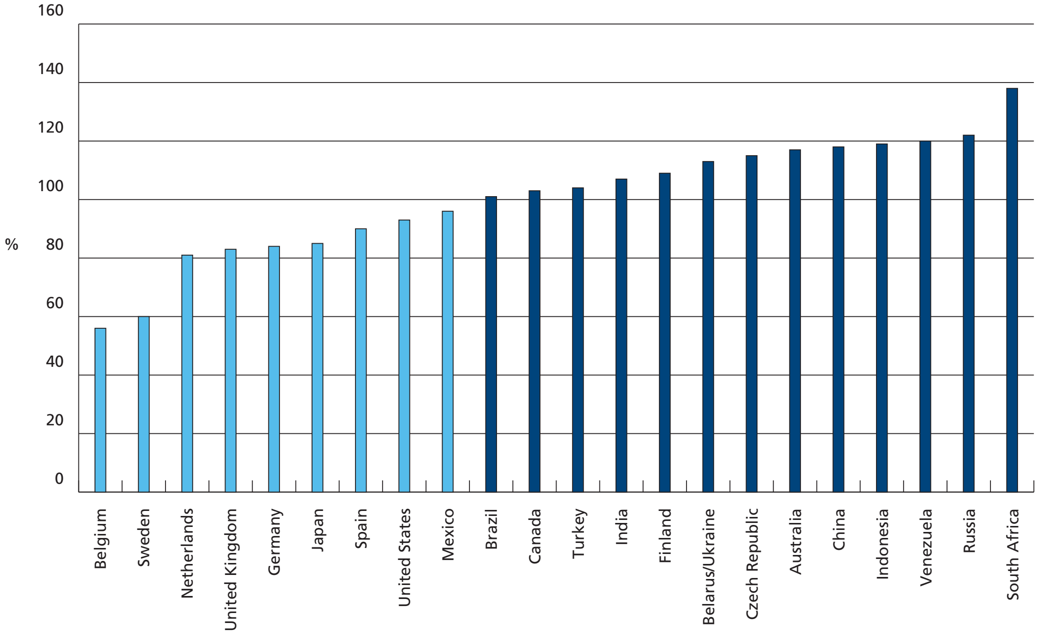
Together the OECD member countries and the five developing countries with the greatest emissions account for three quarters of the world's emissions. In contrast, 700 million people in Sub-Saharan Africa produce less than two per cent of global energy-related emissions – or less than Canada with its population of over 30 million. The EU accounts for about 13 per cent of global emissions.

The role of some developing countries in causing climate change increases clearly when other than energy-related emissions are also included in the calculation. In some years, deforestation of Indonesia alone has caused more emissions than energy use in Latin America and Africa togethe.

Calculations usually consider only the emissions that are generated within the borders of each country. However, some emissions are caused by the consumption of goods manufactured in other countries. Industrialised countries are often net importers of emissions – the countries import products causing emissions more than they export them – while developing countries are net exporters.

An estimated one third of China's emissions stems from production for consumption in other countries. The rise in exports is probably the most important reason for the recent rapid increase in China's emissions. Finland is also a net exporter of emissions, because we manufacture paper and metal products for tens of millions of people. Nevertheless, Finland's total emissions would not change significantly even if imports and exports were taken into account. Calculations are complicated by the fact that, while growing, the wood used as raw material for paper products has sequestered carbon from the atmosphere.

Figure 3.1 Examples of consumption-based carbon dioxide emissions by country



The ratio of production-based and consumption-based CO_2 emissions in some countries in 2001. The countries below the 100 per cent line are net importers of emissions, i.e. the manufacture of products imported by these countries cause more emissions than the manufacture of products exported by them. Correspondingly, the countries exceeding 100 per cent are net exporters of emissions.

Source: Peters, G., Hertwich, E., 2008. CO_2 embodied in international trade with implications for global climate policy. Environmental science and technology 42 (5), 1401–1407.

International climate policy

The First World Climate Conference was organised under the leadership of the World Meteorological Organization (WMO) in 1979. At the conference, climate change was identified as a global threat and states were urged to take action to avert the problem. Policymakers and scientists came together at a climate conference supported by the UN and the WMO in Toronto in 1988. The conference recommended that global carbon dioxide emissions be cut by one fifth by the year 2005.

Four years later, the United Nations Framework Convention on Climate Change was agreed on at the UN Conference on Environment and Development in Rio de Janeiro. The goal set was to keep warming at a tolerable level.

States were committed to protecting the climate in accordance with common but differentiated responsibilities; this means in practice that it is the duty of rich countries to lead the way in limiting emissions. Accordingly, industrialised countries promised to freeze their emissions at the 1990 level by the year 2000. No emission targets were set for developing countries, but all countries are bound by obligations such as monitoring of emissions, development of technology, and promotion of a national climate policy.

The Climate Convention did not lead to the curbing of emissions as had been intended. In 1997 the Convention was supplemented with the Kyoto Protocol, which committed industrialised countries to reducing emissions on average by five percent from the 1990 level by 2008–2012. Legally binding emission targets vary from country to country: from an increase of ten per cent allowed for Iceland to a reduction of eight per cent set for the EU. In addition to the main greenhouse gas emissions, the Protocol covers some of the sinks that absorb the emissions. Obligations can be partly met by purchasing emission reduction units from abroad.

The Protocol has been ratified by all major states except the United States, and it entered into force in 2005. Negotiations on a new agreement for the post-2012 period began at the UN Climate Change Conference in Bali in 2007. The intention is to bring the negotiations to conclusion in Copenhagen in late 2009.

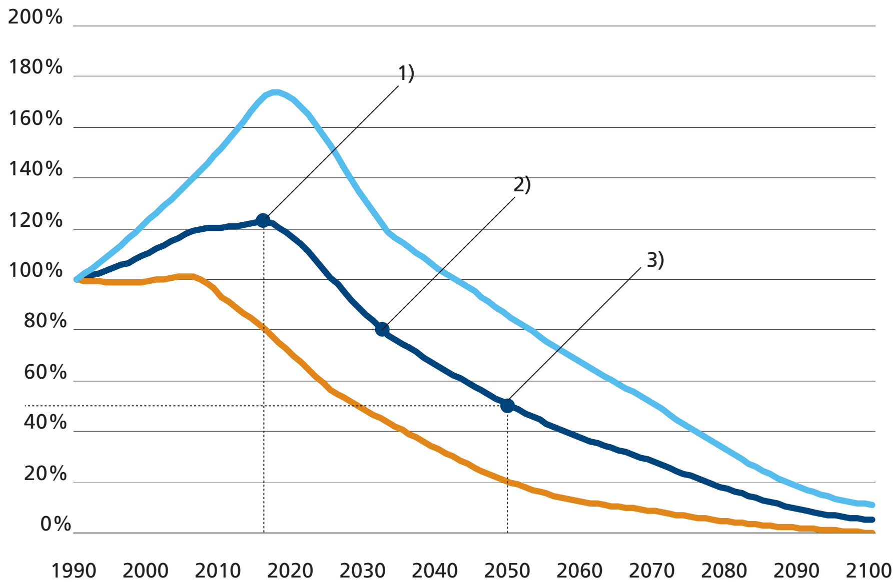
The ongoing negotiations started in Bali are the first to discuss measures taken by both industrialised and developing countries to limit emissions. The agreement should also cover measures to stop deforestation in developing countries, adaptation to the impacts of climate change, technology transfer, and the financing needed to support poor countries.

In international politics, the climate debate has expanded outside the scope of the climate negotiations proper. Climate protection has been discussed by the UN General Assembly, the Security Council and several UN bodies. In conjunction with the Bali Conference, the theme was discussed by ministers of trade and finance. The climate is being mainstreamed and is gaining an established position in all international politics.

Who bears responsibility?

The IPCC has estimated that reaching the target of two degrees with a probability of even 50 per cent requires that rich industrialised countries reduce their emissions by at least 25–40 per cent from the 1990 level already by the year 2020. Within the same time, rapidly growing developing countries should also be able to limit their emissions by 15–30 per cent when compared against the business-as-usual emission level.

Figure 3.2 Emission paths aimed at halving global emissions



Developing countries = Countries not listed in Annex I of the UN Climate Convention
The world
Industrialised countries = Countries listed in Annex I of the UN Climate Convention

1) Emissions peak and start to decline before 2020.
2) On this path, the atmospheric GHG concentration peaks at 550 ppm CO_2 equivalent before 2050 and falls to 450 ppm CO_2 equivalent.
3) A 50% reduction in emissions by 2050.

Source: Meinshausen, M. 2007. Stylized emission path. Background note prepared for the UNDP Human Development Report, 2007.

Warming can be limited to a tolerable level only through immediate, comprehensive and unprecedentedly strong international cooperation. This calls for a solution that various states can consider sufficiently fair – from impoverished African countries to the United States, from small island states to oil producing countries.

The rich countries bear the main responsibility for the warming of the climate. Nearly four fifths of the industrial emissions that have accumulated in the atmosphere so far originate in today's industrialised nations. The United States and the EU have produced over half of global emissions, even though their combined population today accounts only for about one eighth of the world's population.

However, the role of emerging economies and developing countries as emitters is growing quickly. In the baseline scenario of the International Energy Agency

(IEA), 97 per cent of the increase in global energy-related emissions by 2030 will come from countries outside the OECD. Even if rich countries reduced their emissions to zero, the rise in the emissions of developing countries alone would be enough to exceed the global emission level required by the two-degree path within the next few decades.

The emission level per capita varies greatly from country to country. The average for the world's energy-related emissions is four tonnes per person per year. However, in the United States the emission level is 20 tonnes and in India only one tonne. An average Finn produces about 11 tonnes of emissions – nearly three times more than a person in China and 40 times more than a person in Bangladesh.

There are also considerable differences within countries. Even though the average emission level per capita is still low in India, it has been estimated that the emissions produced by the 150 million wealthiest Indians already exceed the sustainable level. Similarly, the poor in industrialised countries typically account for a lower percentage of emissions than the national average.

The emission intensity among households also varies significantly. For instance, for each euro of the GDP, Ukraine produced six times more emissions than the EU. Because of the economic structure, the emission intensity of the Finnish economy is slightly more than one fifth greater as compared to the EU average. Internationally, the most emission intensive countries are the former Socialist countries, oil producing countries, and emerging developing countries dependent on coal, such as China and South Africa.

Fair burden sharing

At present, the international community is fairly unanimous about the need to achieve a notable reduction in global emissions. Politically the most challenging task is to distribute global emission reductions among countries. When discussing burden sharing, four criteria are often presented.

A solution based on historical responsibility would allocate emission reductions, in particular, to countries that have caused the warming so far. This would mean very heavy emission limits for countries that were among the first to industrialise, such as the UK. On the other hand, developing countries that are currently increasing their emissions rapidly would hardly have to restrict their emissions at all.

Burden sharing based on the ability to pay would take account of each country's level of economic development. Countries that can best afford it would reduce their emissions the most. However, this model would also require considerable emission reductions from rich countries that generate relatively little emissions. Correspondingly, few restrictions would be imposed on relatively poor countries that generate a lot of emissions.

In the third approach, the burden can be shared so that the goal is to achieve equal marginal costs. This would ensure that climate objectives are attained in the most cost-effective manner globally. The McKinsey consultancy has estimated that China has as much economic emission reduction potential by 2030 as the United States and Western Europe together. However, the model would require considerable emission reductions in poor countries as well.

The fourth method is to distribute emission allowances equally among the world's population within a certain period of time. The strength of this model is that the global climate resources can be considered to belong to everyone equally; thus, the right to burden the climate should also be divided equally. However, attaining an equal emission level would require very radical cuts in industrialised countries, as well as major emission reductions in emerging economies such as China. When applying the IPCC's estimates of paths that meet the two-degree target, a globally sustainable emission level in 2050 would be 0.75–2.5 tonnes of carbon dioxide per person.

The basic models of burden sharing can be applied and supplemented in various ways. In the sectoral model, emission limits would be distributed among industrial sectors on the basis of the best effectiveness achieved. In the steel industry, for example, the benchmark would be the lowest emission volume per tonne of steel that has been achieved so far. Thus, the model would give a competitive edge to the most efficient companies within an industrial sector.

The sectoral model requires extensive international collection of information and a sector-specific analysis; this increases costs and restricts the applicability of the model. The model is unable to cover all emission sources and therefore cannot replace national emission targets. It might also steer users to select, for instance, the most carbon-effective cement, but not to replace climate-burdening cement by building with wood that absorbs emissions.

Nevertheless, the sectoral model can supplement national emission targets in a few central industrial sectors. The sectoral analysis can also be used as one criterion in burden sharing between countries, and industrialising economies could begin restricting their emissions by imposing sector-specific limits.

A practical approach might be to divide countries into groups on the basis of their level of development and emissions. Industrialised countries, economies in transition and the most affluent developing countries would be subject to quantified emission reduction objectives of the Kyoto type. Emerging economies, such as China, would be required to commit themselves to low-carbon development paths, where the increase in emissions is restricted in relation to business as usual. The poorest developing countries would concentrate on adapting to the impacts of climate change and on advancing sustainable development with the assistance of rich countries.

Reliable input data is important in burden sharing. Estimates of emissions concerning land use, forestry and land use change are particularly uncertain. Therefore, in order to achieve equity, measures must be taken to ensure that the input data affecting emissions and sinks is on an adequate scientific basis.

In the long term, all countries must have low-carbon strategies. In the future, requirements can perhaps also be set directly for major companies.

According to the EU, at least four criteria should be applied in burden sharing between industrialised countries:

1. The ability to pay for emission reductions in one's own country and to buy emission reductions from abroad
2. The emission reduction potential
3. Early measures to reduce emissions
4. Population changes and the overall emission level

Box 3.1 Greenhouse Development Rights Framework

Together with NGOs, the Stockholm Environment Institute has developed the Greenhouse Development Rights Framework (GDR), in which emission reduction and financing obligations would be distributed according to the responsibility and capacity of each country. On the one hand, the model strives to keep global warming under two degrees; on the other hand, it acknowledges the right of poor countries to develop.

Responsibility would be calculated on the basis of the emissions that the population exceeding a certain level of development has generated since 1990. Correspondingly, capacity would be calculated on the basis of the income of the segment of population living above a certain development level. In this way, countries would be ensured a basic level of development before they are required to restrict their emissions.

The model produces startling results. The GDR would require the EU to cut emissions by more than 100 percent by the year 2025. Most of these cuts should be implemented by financing emission reductions in developing countries. On the other hand, financing provided by rich countries would enable the necessary emission reductions in countries such as China and India.

The role of Europe and Finland in the global community

Even though the global community has woken up to the climate crisis rather sluggishly, much has happened around the world in recent years. It can be expected that the pace of climate protection will accelerate when the full effect of international agreements, national goals and emissions trading systems starts to be felt. Finland must actively follow the progress of leading countries.

Table 3.1 Examples of climate policy in some countries in 2007–2009

Country	Policy
Australia	A ban on incandescent lamps A fund of 500 million Australian dollars for renewable energy
Brazil	A national climate programme where the objectives are to reduce energy consumption by 10% by the year 2030, to increase the capacity of renewable energy production by 7,000 MW by 2010, and to stop deforestation by 2015
China	A national climate programme where the goal is, among other things, to reduce the energy intensity of the economy by 20% and to increase the area covered by forests by 20% by the year 2010 New energy efficiency requirements for buildings with a reduction of 50% when compared against the mean level in the 1980s
Germany	A national climate programme with 29 regulatory and financing projects for various sectors and with the objective of reducing emissions by 40% by 2020 A separate fund for energy efficiency consultation and loans for SMEs
Holland	Environmental tax on flights departing the country An energy efficiency programme for buildings (to increase the energy efficiency of 500,000 buildings by 30% in 2008–11) A renewable energy programme for buildings
India	A national climate programme with actions for energy efficiency, renewable energy and reforestation Feed-in tariffs for solar and wind power; wind power target 10.5 GW in 2012 Energy efficiency requirements for new buildings
Indonesia	A national climate programme where the goal is to increase the share of renewable energy to 17% by 2025 and to 30% by 2050, and to afforest 36 million hectares of land suffering from deforestation
Japan	A national energy conservation programme with actions pertaining, for instance, to the energy services of households and industry, the energy efficiency of buildings, and the scope of application of the Energy Conservation Act New standards for the fuel consumption of vehicles
Mexico	A national climate programme where emissions will peak in 2012, after which they will be reduced by 50% by the year 2050
New Zealand	Emissions trading since 2008 for some forests and from 2010 for energy generation and industry An energy efficiency programme for homes, transport, State administration and enterprises; the goal is to achieve savings totalling 205 PJ by 2025. An energy programme where the goal is to raise the share of renewable energy to 90% by 2025
Norway	A carbon neutrality programme with investment subsidies, taxes, development of public transport and support for preventing deforestation in developing countries A bioenergy strategy with new investment subsidies, requirements for public buildings and R&D support Feed-in tariffs for wind, hydropower and bioenergy
South Africa	Feed-in tariffs for wind, small-scale hydropower, biogas and solar power
Sweden	Government strategy where the goal set for 2020 is to cut emissions by 40% outside emissions trading, to improve the efficiency of energy use by 20%, and to raise the share of renewable energy to 50%
United Kingdom	A Climate Act with binding emission targets and related measures An Energy Act with feed-in tariffs and the authorisation to increase support for renewable heat
United States	An increase of USD 800 million in tax support and other subsidies for renewable energy, and USD 800 million for energy efficiency in 2008 In the budget proposal for 2010, a total of USD 150 billion for clean energy during ten years, emissions trading, and phasing out of support for fossil fuels; USD 16 billion for the energy efficiency of buildings

The European Union – the most important cooperation forum in climate policy for Finland – has consistently been the engine for international climate protection. It can be considered that the persistence of the EU was the main reason why the Kyoto Protocol came into being and how it survived the precarious years following the disengagement of the United States. The target of restricting global warming to at most two degrees – which has gained increasing popularity in negotiations – was also originally presented by the EU.

The EU emissions trading system can be regarded as the world's most extensive climate policy measure, and it serves as a model in many other areas. Even with its shortcomings, the EU climate and energy package adopted in late 2008 contains the most ambitious targets and measures approved on a large scale anywhere. In this package, the EU is committed to cutting its emissions by 20 per cent from the 1990 level by the year 2020 in any case, and by as much as 30 per cent if the other key countries agree to join in.

Without the EU's constant leadership, it is hardly possible to reach sufficiently ambitious agreements. Thus, the Union should continue in its role as the locomotive for climate protection. Finland supports and strives to strengthen the EU's role as a leader in this field. At the same time, it is necessary that other major countries also participate in emission restrictions constructively.

In addition to an active approach and initiative in international climate policy, the EU must also show proof of success in the home field in order to maintain its leading position. The EU Member States – including Finland – must be able to show credibly that they are advancing towards the climate and energy targets that they have themselves adopted. A sufficient share of emission reductions must be achieved cost-effectively within the Union.

Even though Finland's emissions are high in relation to the population and the economy, Finland only accounts for a few per mill of global emissions, and even this share is shrinking. However, a small country can also influence global developments by working in a determined manner to become a leader in climate protection and by showing the way to other countries. The Nordic countries can develop and apply sustainable solutions and commercialise sustainable technology that can be utilised throughout the world.

Climate protection and foreign policy

Climate change is a worldwide economic, social and political issue and, increasingly often, a security issue. The problem can only be solved through extensive international cooperation that can be furthered by means of foreign policy. For a political signal, it is particularly important to ensure the continued commitment of top political leaders, but climate diplomacy should also be realised in external relations at all levels.

Finland promotes international climate protection especially as an EU member and works actively to integrate the climate perspective in all multilateral cooperation. Important international forums include UN bodies and conventions, the World Trade Organization, and international financial institutions, such as the World Bank and regional development banks. Among regional forums, the most important for Finland are the Nordic Council and the Arctic Council. Less formal forums, such as the Major Economies Forum (MEF), have also emerged to supplement the official organisations.

Climate protection is also likely to require changes in the structures of global governance. The UN system must be revised and institutions supporting climate conventions must be strengthened. Credible monitoring mechanisms and sanctions must be sought for future conventions. Today the World Trade Organization has the strongest enforcement system; thus, there may be a need to strengthen its links to climate conventions. Finland has also long supported the proposal to strengthen the UN Environment Programme by establishing a United Nations Environment Organization (UNEO).

Many of the adverse effects of climate change – such as food and water shortages, poverty and forced migration – may aggravate conflicts, and in extreme cases may even trigger them, especially in poor and fragile countries. In terms of security, climate change may act as a threat multiplier. On the other hand, climate protection means increased interdependence; this may also help solve security problems.

Climate security requires measures that in most cases would be justified in any case. These include, among others, the strengthening of international cooperation, advance prevention of crises, civilian crisis management, and advancement of sustainable development in poor countries.

The impacts of climate change on Finland's security are mainly indirect and are likely to appear mostly over the long term. If global warming makes the world a more miserable and less stable place, many of the consequent threats will affect Finland, too. However, some of the impacts, such as more frequent or more intense extreme weather phenomena, may weaken the possibilities of maintaining society's basic functions already in the short term – at least temporarily.

Climate change is a cross-cutting theme in the Government Report on Finnish Security and Defence Policy, adopted in early 2009. The climate perspective should be strengthened further and made more concrete in the national security and defence policy. Similarly, proposals to discuss the climate in international security forums, such as the UN Security Council, should be supported.

Trade policy and technology transfer

International trade and the climate are linked with each other in many ways that are partly contradictory. Unrestricted climate change may lead to a global economic recession and to the impairment of international relations; this would seriously deteriorate the prerequisites for trade. On the other hand, climate criteria may lead to higher transport costs and to trade restrictions imposed on the products of free rider countries.

Free trade can be considered a precondition for the efficient transfer of sustainable technology and innovations from one country to another. On the other hand, liberalising trade may make climate protection more difficult if it spurs economic activity giving rise to emissions and, in particular, international transports.

The climate perspective has been rather inconspicuous in international trade policy. The EU has advocated the position that trade and environmental agreement systems should be equal; in other words, neither would be subordinate to the other. The WTO could also play a role as a regulator of international emissions trading. The aim should be that the prices of all products reflect their real costs to society.

International transports should also be given a price reflecting their climate impacts. This could be done either through emissions trading or international taxes. This would ensure that no producers get an unfair competitive edge by externalising costs for others to pay. The primary objective must be a comprehensive, international solution, but the EU is ready to proceed independently if the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) are unable to agree on emission limits. The system can take into account the importance of transports for the economies of remote areas and the least developed countries.

Deregulation of trade in climate-friendly products, technology and services will expand the market, increase the benefits of scale associated with specialisation, and thereby help to improve supply and to lower prices. The World Bank has estimated that elimination of trade-restricting duties and technical barriers for no more than 12 products would increase the exports of clean technology to developing countries by 14 per cent. Trade in products and services that help protect the climate should in fact be made easier.

In the climate conventions, industrialised countries are committed to promoting the transfer of sustainable technology to developing countries. Developing countries have considered that implementation of the commitments so far has been insufficient. Poor countries emphasise the role of the public sector, whereas rich countries prioritise technology transfer between enterprises on commercial terms.

In future climate conventions, technology transfer must be stepped up markedly, and permanent and functional solutions must be sought for ensuring sufficient funds for it. Support is also needed for improving the investment climate and capacity of developing countries so that they can receive and utilise new technology.

Intellectual property rights guarantee compensation for technology, thereby providing an incentive for developers of solutions. Countries where rights are neglected are not usually attractive for enterprises selling technology. However, on commercial terms the price of sustainable technology may rise so high that poor countries have no possibilities to take it into use.

According to an assessment made by the European Commission, licence fees do not usually restrict technology transfer to any significant degree. Studies on the distribution of technologies preventing ozone depletion also indicate that intellectual property rights constitute a major hindrance only in exceptional cases.

However, if there are good grounds for assuming that the rights slow down the transfer unreasonably, new means for balancing the interests of developers and users should be sought within the WTO. Even then, measures should primarily be selected so that they do not weaken technology developers' trust in the protection of their rights in user countries.

Helping poor countries

Climate change threatens the results achieved through decades of development cooperation and the developing countries' own efforts in furthering their human development. One hurricane or flood can turn the clock of development back by years. Sustainable development in developing countries is possible only if climate change can be contained at a tolerable level. On the other hand, the combat against climate change does not lead to sustainable results if poverty is not diminished.

Development cooperation plays an important role in the advancement of climate protection, especially in the least developed countries where market mechanisms function inadequately. On the other hand, its impacts may be only limited. In 2007, industrialised countries used about USD 104 billion for official development assistance. The 20 largest countries outside the OECD alone spent nearly three times that sum for energy subsidies. In fact, development that is sustainable for the climate also requires that developing countries themselves show commitment and revise their policies.

Development cooperation supports developing countries' participation in the joint effort to combat climate change in many ways. It can help developing countries, for instance, to draw up adaptation plans, to make emission inventories, to host climate projects and to participate in international negotiations. Development cooperation is also used to support practical projects that limit emissions and promote adaptation, for instance, in the production and use of energy and in agriculture and forestry.

However, in some cases development cooperation can increase the load on the climate. For instance, the World Bank Group still spent two thirds of its energy financing in the fiscal year 2008 for promoting the use of fossil fuels. It has also been possible to use development cooperation funds to implement projects that have not made sufficient provision for the consequences of warming. A school may not necessarily withstand the impact of a hurricane, or agriculture has not been adapted to increasingly severe droughts.

Development policy must be evaluated and reviewed internationally so that it supports both the measures to combat climate change and adaptation to its consequences more strongly than at present. In other words, development cooperation calls for climate proofing.

Developing countries must be supported in adopting low-carbon development paths. Instead of fossil fuels, public development funds must be directed towards improving energy efficiency as well as using renewable energy and sustainable forest management. When funding climate projects, the general principles of development policy must be followed to the extent possible. Market mechanisms resembling the current Clean Development Mechanism can support low-carbon paths, especially in rapidly developing countries.

Finland's Development Policy Programme emphasises environmental issues and especially climate issues as a central element of sustainable development in the wide sense. The long-term goal is carbon neutral development cooperation. The urgency of the global climate crisis gives cause to redouble efforts to reach this goal.

A lesson learnt in development cooperation is that development should be seen as a whole. If climate issues are not linked to developing countries' own plans, such as poverty reduction strategies, there is a lack of ownership on the part of developing countries and the results will not be sustainable. Sustainable development in general, and the climate in particular, must be taken into account in the development plans of partner countries more explicitly than at present.

The preparedness of developing countries to pursue a sustainable climate policy nationally and in international negotiations must be strengthened, for instance, by training and by improving the knowledge base. One possible tool in developing countries would be to support the compilation of certain types of national Stern reviews, i.e. assessments of the costs of climate change, on the one hand, and the costs of emission reductions, on the other. Results are obtained faster by improving the prerequisites for good governance and by adopting best practices.

Deforestation must be stopped

A little less than one fifth of global emissions stems from deforestation and shrinking of the carbon stocks of forests, especially in developing countries. During the first few years of this century, over seven million hectares of forests – an area the size of Ireland – were lost every year. The disappearance of forests was the most rapid in South America, Africa and Southeast Asia whereas in the United States, the EU and China, the forest area is increasing, and in nearly all industrialised countries forests act as sinks.

Emissions from the clearing of peatland rainforests in the tropics correspond to as much as eight per cent of the global emissions of fossil fuels. The carbon dioxide released by the forest fires in Indonesia in 1997–1998 alone corresponded to two fifths of the annual emissions of fossil fuels. Peatland rainforests face many threats, such as clearing to give way to the production of palm oil and illegal felling, as well as the clearing of land and slash and burn practised by small farmers.

The international community has long struggled to prevent deforestation in developing countries and to promote sustainable forestry. The Non-legally Binding Instrument on All Types of Forests, adopted by the UN General Assembly, stresses that forests contribute significantly to the strengthening of sustainable development and to the eradication of poverty. However, factors such as lack of funding have made it more difficult to find solutions to the problem.

Combating climate change requires that deforestation be stopped and sustainable forestry and land use be adopted. The Stern Review estimates that the costs of halving deforestation are about USD 6.5 billion per year. The European Commission's estimate is EUR 15–25 billion per year; this includes the dynamic impacts on the prices of forest and agricultural products. Even then the costs of emission reductions would be relatively low, USD 10–20 per tonne of carbon dioxide.

For many developing countries, bringing deforestation to a halt and adopting sustainable forestry are the most important way to participate in the joint effort to combat climate change. When developing countries are rewarded for measures to prevent deforestation, they may take a more positive attitude to a comprehensive climate convention; this, in turn, may support the setting of more ambitious global emission targets. Attaining real emission reductions requires that measures taken in one area do not lead to the acceleration of deforestation elsewhere and that the emission reductions achieved are permanent. The monitoring system must be strong enough so that the effectiveness of the measures can be guaranteed.

In international cooperation, the target should be to stop global deforestation and to achieve an upturn in the net area of forests, for instance by promoting sustainable forestry, by 2020 at the latest, in line with the earlier commitments of the EU and Finland. The emphasis should be on the most valuable areas in terms of the carbon balance and biodiversity. The parties to climate negotiations must seek a well-functioning mechanism that can be used to support developing countries in the sustainable use and protection of forests. In its own development policy, Finland supports this goal.

A balanced population trend supports climate protection

Apart from a rising standard of living and industrialisation, population growth is another central factor increasing emissions. According to the UN’s middle-of-the-road estimate, the world’s population will increase by nearly three billion, or to nine billion, by 2050. On the path of slow population growth, the figure would remain under eight billion, whereas rapid growth could raise it to over ten billion.

According to one estimate, population growth will account for half of the increase in global emissions until 2025. By mid-century, the path of slow population growth could spare over 11 billion tonnes of carbon dioxide in annual emissions; this is the same amount that China and the United States together now produce through their use of fossil fuels.

In the end, constant population growth is an impossible path in terms of both human development and the capacity of the climate. The relatively fast population growth that still continues in some rich countries burdens the climate more than average because these countries have a high emission level per capita. Uncontrollable population growth in poor countries exacerbates poverty and often feeds deforestation.

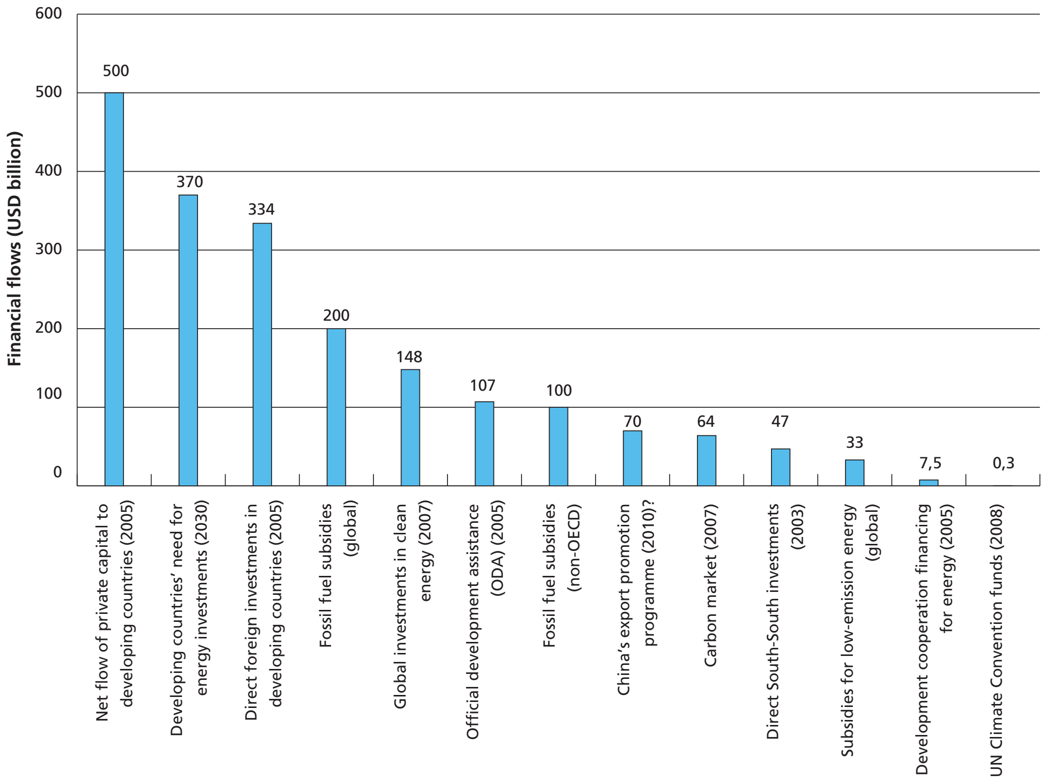
The population trend can be balanced best when human basic needs have been met to a sufficient degree, when a wide range of high-quality sexual and reproductive health services is available, and the public opinion supports reasonable family sizes. The education and empowerment of girls and women play a key role.

From the perspective of climate protection and the promotion of human development, it is justified to allocate more funding and to direct a larger share of development cooperation at efforts to balance the population trend. This is supported, for instance, by primary health care, education of girls, improving the position of women and by making contraception services available more widely.

Financial challenge

Climate work will cause major costs for developing countries, costs that they cannot bear alone. According to an estimate made by the UN Development Programme, developing countries will need USD 25–50 billion of additional funding per year for limiting their emissions. According to the International Energy Agency, the sum may rise to 65 billion in 2030. The World Bank has estimated that adaptation to warming will require USD 10–40 billion in 2030; the development organisation Oxfam believes that the sum will be at least 50 billion per year.

Figure 3.3 Climate funding in proportion to other global flows of funds



Approximation of the annual investment flows and financial flows.

Source: Greenstream. 2008. Kansainväliset ilmastoneuvottelut. Investointi- ja rahoitus-kysymykset. Loppuraportti 28.9.2008. [International climate negotiations. Investment and financing issues. Final report, 28 September 2009] p. 25.

In total, developing countries' need for financing for climate purposes is estimated to range from some tens of billions of dollars to over a hundred billion dollars per year. Thus, the need for additional funding could be of the same order as the funds used annually for development cooperation.

No source alone can meet such a major need. What is needed is both public and, to an increasing extent, private funding; both support from industrialised countries and investments by developing countries themselves. The funding must also be adequate, predictable and sustainable.

According to a preliminary estimate made by the Ministry of Finance, Finland's share of climate funding for developing countries could be about EUR 100 million per year in 2020. With pessimistic assumptions, the maximum sum might be as much as EUR 400–500 million. The need for support will continue to grow by 2030.

A major part of the funding for restricting emissions in developing countries can be obtained from the private market, from emissions trading and as direct investments in sustainable technology. The availability of private funding can be facilitated by means of international loans. In contrast, it is difficult to obtain funds directly from the market for adaptation to climate change.

New and innovative sources should also be considered for collecting sufficient funds. In connection with the EU climate and energy package, it was decided that some of the revenues from the auctioning of allowances in the Union's emissions trading scheme should be used to support climate work in poor countries. Norway has proposed that some of the emission allowances in the coming climate convention be auctioned internationally. Mexico has proposed a system based on financial commitments for all countries. Switzerland has brought up the idea of a global carbon tax, whereas the group of the least developed countries has proposed levying a tax on international airline traffic or fuels.

With such considerable currency flows, special attention must be paid to the results of actions, cost-effectiveness, coordination, good governance and reliable monitoring. In the main, the existing channels should be utilised when channelling funds. The commitment of recipient countries and their participation in decision-making must be improved. It is also important to direct the support so that the primary focus is on the most vulnerable countries and population groups.

Publicly funded climate actions taken in developing countries meet the criteria of official development assistance. Because adaptation to warming requires development, in practice it is sometimes almost impossible to say when a development project ends and a climate project begins. Development cooperation funds are also used to support climate negotiations and the participation of developing countries in them. Finland's focus is on improving the participation of women, both in international climate policy and in the national climate policies of developing countries.

Box 3.2 Ecological debt

Poor countries have owed considerable sums to rich countries. In contrast to this traditional debt, a new concept has been introduced: ecological debt, where rich countries owe to poor countries for their overuse of common environmental resources. Industrialised countries have spent the bulk of humankind's common carbon budget and have left only a fraction of it to developing countries and future generations.

Ecological debt can be defined, delineated and calculated in many different ways. The development organisation Christian Aid has divided climate responsibility in relation to each country's population, income, possibilities of reducing emissions, and emissions since 1992. The global climate debt has been defined so that it is the price of measures taken to combat and adapt to climate change; this is estimated at about one per cent of the GDP. Calculated in this way, the European Union's climate debt is slightly over USD 200 billion.

It is anticipated that climate change will aggravate problems such as drought or hurricanes, which give rise to direct and possibly considerable financial expenses. As industrialised countries have caused most of the global warming seen so far, the question arises whether they have the duty to compensate poor countries for the adverse effects of climate change.

The Government's policies

- Determined effort is made to achieve comprehensive and effective agreements in climate negotiations. Finland sets an example, developing and adopting sustainable solutions that can also be applied in climate protection elsewhere in the world.
- The goal of the negotiations is to achieve fair burden sharing so that all key emitters can be made to join the effort to restrict emissions. The path of the two-degree target is followed in order to cut the emissions of industrialised countries and to limit the emissions of developing countries so that the per capita emissions of various countries approach a sustainable level over the long term.
- Effort is made to support and strengthen the European Union's leading role in international climate protection. Finland takes an active approach and shows initiative in climate negotiations.
- Finland works actively to strengthen the climate perspective in international cooperation in all forums. The climate is integrated more closely with foreign policy and all bilateral relations.
- The international institutions of climate protection are strengthened, and the reform of the UN system is supported to promote this goal. Developing countries are aided in their efforts to improve climate policy preparedness and to participate in climate negotiations.
- Trade that promotes climate protection should be liberalised without delay. Gaining an unfair edge in competition by avoiding climate obligations must be prevented, for instance, in the WTO.
- The price of international transports must reflect the costs of the resulting emissions.

- The transfer of climate-friendly technology to developing countries is accelerated markedly, for instance, by improving developing countries' capacity for receiving technology. Carbon neutral development cooperation will be introduced as soon as possible.
- The concept that development funding should be sustainable in terms of the climate is promoted in international development banks and other forums. Public development funding for the use of fossil fuels causing emissions will be gradually phased out.
- One goal is to stop global deforestation and to achieve an upturn in the total area of forests, for instance by promoting sustainable forestry, by 2020. Poor countries are supported in attaining this target.
- Development cooperation balancing the population trend is prioritised and increased also for climate reasons. The special areas of focus are providing basic education, ensuring the availability of sexual and reproductive health services, and improving the position of women.
- Considerable extra funds are needed to support climate work in developing countries. Provision is made to increase public funding in line with Finland's own fair share, as part of the international agreement in the making.
- New and innovative means, such as the utilisation of revenues from the auctioning of emission allowances, are considered in order to collect sufficient funding.

4 PATHS TOWARDS A LOW-CARBON FINLAND

The background scenarios included in this foresight report are meant to provide material for debate by giving examples of potential low-carbon paths. The scenarios show that Finland can reduce emissions by at least 80 per cent by 2050 in many different ways. For example, urban structure[1], the share of nuclear power, and industry's energy needs can be very different in a low-carbon Finland. In practice, however, all paths require the adoption of energy and transport systems with nearly zero emissions. Each scenario has its own strengths and challenges; none of the scenarios is selected for implementation as such.

Scenarios are plausible and internally consistent descriptions of future developments. They can be used to illustrate the future outlooks and paths that are possible under certain assumptions – concerning policies, technological and behavioural changes, economic trends, or international relations. Scenarios can be used to identify what needs to be done to achieve the desired futures or to avoid the undesirable ones. However, they are not predictions and do not attempt to discern what the future will look like.

Scenarios can be made roughly in two ways. Scenarios based on forecasting strive to anticipate future developments on the basis of past trends, the present situation and future drivers for change. Scenarios based on the backcasting approach describe the desired future and seek paths from the present day towards that future. Both approaches have their advantages, and they can also be applied in parallel.

Scenarios enable comparison between alternatives and stimulate analytical debate. Climate and energy policy scenarios can be used, for instance

- to raise awareness and to increase actors' commitment
- to define the targets needed
- to plan the actions required by the targets
- to outline road maps and the timeline of actions towards the targets
- to identify opportunities and threats
- to assess the effects of various policies and to chart operating environments

Several long-term climate and energy scenarios have been drawn up internationally. The most widely used scenarios are the global SRES scenarios of the IPCC, which examine the trends of global emissions and climate change with no climate policy.

1 For this particular report, 'urban structure' refers to the built structure in both urban and rural communities. In rural communities it refers to the more densely built centres of towns and villages.

VTT Technical Research Centre of Finland has previously studied the possibilities of reducing Finland's emissions by 60–66 per cent from the 1990 level by 2050. The scenarios in this foresight report are the first Finnish scenarios that chart paths towards the emission level required by the two-degree target. This is also the first time when several divergent ways of cutting emissions markedly have been outlined.

The main emphasis in the review of the scenarios included in the Goverment's Long-term Climate and Energy Strategy is on the period extending up to 2020. The baseline scenario that describes trends without new climate policy measures, and the outline vision on energy consumption and emission trends cover the period up to the year 2050. The long-range scenarios in the foresight report provide a parallel and complementary approach to the scenarios in the strategy.

The scenarios in this foresight report serve many functions. They help assess

1. whether it is possible to cut Finland's emissions by at least 80 per cent
2. what sort of different paths can be outlined towards a low-carbon society
3. what changes are needed on all paths, and what is their timetable
4. what strengths and weaknesses the paths have

The target: Cutting emissions by at least 80 per cent

The national long-term target expresses Finland's determination both to actors within the country and to the EU and the international community. By setting an ambitious goal, Finland shows that it is committed to doing its own and fair share of the joint effort to combat climate change. In this way it is easier to persuade other countries to join in.

In 2020, about two fifths of emissions in the EU will fall within the scope of emissions trading. In this sector, the EU-wide emissions trading system is the primary way of guaranteeing that emissions will be reduced. The precise distribution of emissions among Member States follows market mechanisms; it is therefore not easy to predict year by year how much of the reductions allocated to the Finnish emissions trading sector are achieved in Finland and how many emission allowances are purchased from elsewhere.

In any case, the emissions trading system may undergo many changes before 2050. Nor does emissions trading prevent States from setting national targets, which is what many EU Member States have done. In the vision presented in the Government's Long-term Climate and Energy Strategy, Finland's emissions in 2050 will be 70 per cent lower than in 1990.

Finland is committed to the European Union's common goal of cutting global emissions so that warming remains within two degrees. Accordingly, the target set by the Government is to decrease Finland's national emissions by at least 80 per cent from the 1990 level by 2050. The target means that in 2050 Finland's emissions can be at most about 14 million tonnes of CO_2 equivalent – roughly the same amount as is today produced by transport alone.

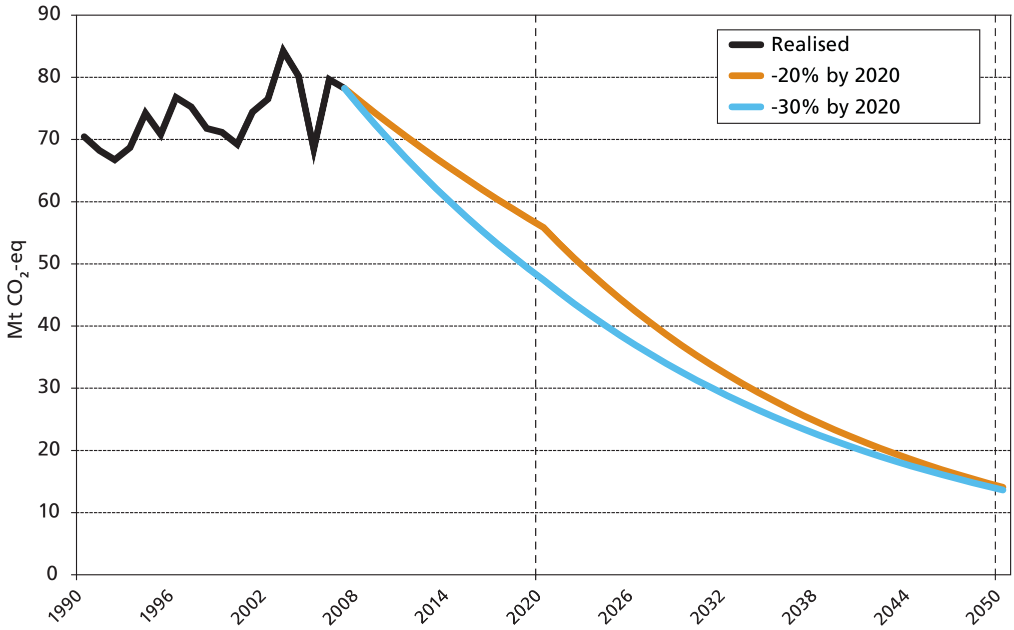
The timing of emission reductions depends on obligations agreed upon, for instance, at international climate negotiations and within the European Union. If the EU keeps to its target of cutting emissions by 20 per cent from the 1990 level by the year 2020, and Finland does not strive towards stricter targets nationally, the emphasis will be on the tail end of the long-term emission reduction path. Starting from the level in 2007, Finland would have to reduce its emissions on average by 2.6 per cent annually until 2020, and by 4.5 per cent annually in 2020–2050.

But if the EU is committed to a more stringent emission reduction rate of 30 per cent until 2020, Finland would have to cut its emissions by about 3.8 per cent annually until 2020 and by 4.1 per cent thereafter. Thus, the need to reduce emissions would remain fairly steady throughout the period under review.

With regard to limiting the risks involved in climate change, it is best to reduce emissions as much and as rapidly as possible because then, if necessary, the chances of reaching low targets for greenhouse gas concentrations are greater. Emphasising the initial phase of the emission reduction path is more efficient for avoiding a carbon lock-in, i.e. investments in structures that bind economies to high emissions for decades to come. On the other hand, as technology develops, some emission reductions may be easier to carry out in the future than now.

The reduction of at least 80 per cent is at the lower end of the range (–80–95%) estimated by the IPCC for industrialised countries in accordance with the two-degree target. The reduction is in line with the positions taken by the European Commission, the European Parliament and the Council. Besides the EU, other industrialised countries must be committed to comparable emission reductions, and emerging developing countries must bear their own responsibility in accordance with their level of development. The target is also of the same order of magnitude as in many leading countries, thereby supporting the target expressed in the foresight report to raise Finland to among the leaders in the field of climate protection.

Figure 4.1 Some illustrative paths outlined towards the target in 2050



The descriptions of the paths do not take a position on whether the emission reduction targets are achieved through domestic measures or partly by financing emission reductions elsewhere. If emissions trading or flexible mechanisms are utilised for reaching the emission targets, domestic emission reductions will be correspondingly smaller.

Table 4.1 Emission targets of some countries by 2050

Country	Target	Comments
Maldives	–100%	carbon neutral by 2020
Costa Rica	–100%	carbon neutral by 2021
Norway	–100%	carbon neutral by 2030
New Zealand	–100%	carbon neutral by 2040
Sweden	–100%	carbon neutral
UK	–80%	minimum target determined in the Climate Change Act
United States	–80%	President Obama's proposal

The targets have been calculated from the emission levels in 1990. Carbon neutral means a situation where a country produces no net emissions. In such circumstances, the amount of emissions generated is very small, and the remaining emissions are offset by carrying out emission reductions elsewhere.

What determines the future paths?

Future developments depend on a number of factors. Finland can affect some of these factors directly and substantially, while others can be affected only indirectly and slightly.

The basic variable is the population. The amount of emissions is more or less directly correlated with the population. The scenarios of the foresight report assume that the Finnish population will grow from the present 5.3 million to 5.7 million by 2050.

The pace of economic growth has a major impact on the amount of emissions. The economic structure determines how carbon-intensively the growth is achieved. The scenarios of the report make varying assumptions about economic trends, but all of them indicate that the Finnish economy will grow markedly by 2050. Industry will be modernised and the volume of services will grow. In the transition towards a low-carbon society, the link between the economy and emissions will become weaker and economic growth will equal increasing emissions less often.

Technological development will also play a crucial role. All scenarios assume that low-carbon technology will develop rapidly and that energy efficiency will improve in all sectors by 2050.

The prices of various energy types affect their relative shares. The more expensive fossil fuels are, the greater the competitiveness of low-carbon alternatives. The scenarios assume that the prices of fossil fuels will rise as their reserves diminish, whereas the prices of sustainable solutions will fall as technology develops and is commercialised.

The set of values people have is difficult to determine. People's values and attitudes keep changing in the future too, and this affects behaviour and policies. It can be assumed that, as climate change progresses, Finns' preparedness to take action to restrict emissions will increase.

Similarly, progressing climate change will affect the prerequisites of climate policy. In Finland, climate change is expected, for instance, to reduce the need for heating, to increase the production of wind power, hydropower and biomass, and to improve the prerequisites for agriculture. At the same time, however, many risks will increase. The scenarios assume that global warming will proceed according to the two-degree path.

Finland's paths as part of the world

International developments affect the preconditions for Finland's climate policy in many ways. The larger the group of countries committed to emission restrictions is, the smaller the threat to competitiveness becomes. International climate cooperation accelerates the development of sustainable technology and reduces its price by expanding the markets for sustainable solutions.

In many cases, reducing emissions brings long-term benefits irrespective of what measures other countries take. However, Finland generates such a small percentage of global emissions that very low-carbon paths in this country are sensible only as part of extensive international cooperation. Unless the rest of the world participates in the joint effort to an adequate extent, not even radical measures taken by the whole of Europe would be enough to restrict warming sufficiently.

The background scenarios of the foresight report assume that all principal emission-producing countries will take part in climate action. Moreover, the scope of the work did not allow the drafting of different global scenarios that would have examined other alternatives.

If strong climate agreements are to be reached, determined efforts are needed, and Finland is committed to this work as part of the EU. Certainty of climate science, public awareness, the commitment of political decision-makers, and the development of sustainable solutions improve the possibilities to proceed in international climate policy.

Provision must also be made for risk scenarios. We may face a less stable world where there is more strife over diminishing natural resources, and where inequality and poverty gain ground. Attitudes may become harsher, international cooperation may become crisis-prone, and States may withdraw into their shells. In such circumstances, it would be virtually impossible to restrict climate change to a tolerable level.

Population growth, the need to improve the security of food supply, and changes in consumer behaviour will increase the global demand for food in the future. This trend is also reflected in the Finnish agriculture and thereby in the prospects of climate protection in agriculture. However, when the scenarios were outlined, there was no material available that would have made it possible to take the increased demand for food into account.

How were the scenarios drawn up?

The goal of the background scenarios in this foresight report is to sketch some possible paths towards a low-carbon Finland and present them as examples. They help us to assess how emissions could be reduced to a sustainable level in practice. The scenarios supplement, specify and illustrate the long-term vision presented in the Government's Long-term Climate and Energy Strategy.

The scenarios are meant to reflect various views concerning potential solutions that have come up in the political debate. In order to stimulate discussion, a conscious effort has been made to seek very different ways of achieving the desired outcome; for this reason, some choices may seem surprising or radical.

There has been no attempt to make any scenario more realistic or more attractive than others, and all paths have their weaknesses and strengths. In all probability, the policy outline selected in the coming decades will be a combination of the best features of all scenarios.

The desired objective of the scenarios was set first: A Finland that, through international cooperation, has managed to cut emissions to a sustainable level in 2050. Thereafter, paths have been outlined towards that objective (backcasting).

The scenario work combines qualitative and quantitative approaches. Futures have been presented as storylines, each of which has striven to create a single, internally consistent image of a low-carbon Finland. By means of calculations done by consultancies, the images of the future have been converted into numerical values and their energy consumption, energy sources and emissions have been examined. This has made it possible to test the consistency and functionality of the paths, to identify any problem points that might exist, and to assess whether reaching the emission target is realistic.

Various assumptions, for instance, on the final energy consumption and the percentage of nuclear power serve as input data for calculations. Owing to the uncertainties stemming from the long time range, the goal was not to produce detailed calculations but to get an overall idea of orders of magnitude. Following the calculations, the scenario descriptions were revised and adjusted.

The scenarios focus on Finland's national greenhouse gas emissions, and the emission target is reached through national measures. The sinks that absorb emissions, and emissions that have an indirect effect on the climate, were excluded from the analysis.

The calculations have taken into account the impacts of climate change on the need for heating and cooling and on the production of hydropower and wind power. In contrast, owing to the uncertainties involved, the calculations do not include the boosting effect that warming may have on bioenergy production through accelerated growth of forests and field-cultivated plants. Uncertainties in emission calculations are also reflected in the calculations made for the scenarios. For instance, it is difficult to measure emissions pertaining to the soil, and they involve many uncertainties.

The ministerial working group and the group of experts oversaw the preparation of the scenarios at the general level. The ministerial working group defined the principles of the scenario work:

1. the scenarios lead to a sustainable emission level
2. the scenarios must present genuine alternatives
3. the scenarios must enable open assessment of alternatives
4. several different methods are applied in the scenario work

The Government has taken no position on the details of the scenarios, nor has it selected any of them for implementation.

The resulting images of the future reflect the views obtained during a multi-stage process:

- online survey at otakantaa.fi (government online discussion forum) in late 2007
- stakeholder panels in spring 2008
- scenario workshops and an online survey in autumn 2008
- expert workshops at the turn of the year 2008–09
- an extensive online survey in early 2009

With the help of consultants, preliminary scenario descriptions were drafted on the basis of the workshops and online surveys. Development paths were reworked in expert workshops in order to sharpen the differences between the scenarios and to improve their consistency and credibility. The general public was asked to give their views of the scenarios in an online survey. At the calculation stage, some necessary adjustments were still made to the scenario descriptions.

Box 4.1 Potential paths for a low-carbon Finland

Experts have drawn up four scenarios for the foresight report. Serving as examples towards a low-carbon Finland, these paths were named after their leading ideas: Efficiency Revolution, Sustainable Daily Mile, Be Self-sufficient, and Technology is the Key.

The paths differ from each other with respect to several factors. In a low-carbon Finland, features such as final energy consumption, economic structure, regional and urban structures and modes of energy production can be very different. On the other hand, some factors are common to all paths.

The results of the scenario work have been described in Appendix 1 at the end of this report. The Government does not take a position on individual scenarios and their assumptions.

First, the Appendix presents the energy consumption by sector for each path. This is followed by an analysis of the alternative ways of meeting the need for energy obtained during the scenario work. The analysis encompasses the production of electricity and heat, the shares of domestic energy and energy based on imports, and the various forms of energy.

The volume and distribution of greenhouse gas emissions in the various scenarios have been calculated on the basis of the energy consumption and production data and supplementary sectoral estimates. The figures obtained for each sector are compared against the present situation, and the resulting sums are compared against the emission target set for 2050.

Challenges and opportunities existing in energy use and production and in the emissions of various sectors are discussed on the basis of the results. The paths are assessed from the viewpoints of the economy, fairness and the environment. The Appendix also presents opinions about the scenarios expressed by the general public through an online survey. Finally, some possible ways in which the actual development taking place may deviate from the descriptions presented in the scenarios are discussed.

Conclusions for Finland

The scenarios differ from each other markedly in many respects. However, some measures seem to be necessary irrespective of which future path is selected.

The starting point of all paths towards a low-carbon Finland is the progression of global efforts to curb climate change. It is therefore necessary to do everything possible so that as comprehensive a group of countries as possible will be committed to sufficiently strict emission limits.

Marked improvement of energy efficiency is necessary in all sectors irrespective of the energy sources utilised to meet the need. This requires, among other things, stricter building standards leading towards the zero energy level. Requirements also need to be set for renovations. Owing to the slow renewal rate of the building stock, the targets set for 2050 must already be taken into account when houses are built in the 2010s. More stringent efficiency standards need to be set at EU level for household appliances and other equipment.

The development, deployment and diffusion of low-carbon technology is needed on all paths. Technological leaps are necessary especially in the energy-intensive industry and in the transition to bioeconomy. This calls for additional input in research and development, international technology cooperation, and policies and measures that generate domestic markets.

In all scenarios, much more renewable energy is needed. This additional use of bioenergy requires more efficient harvesting and storage and the training of workforce. Moreover, new solutions are needed to integrate great volumes of wind into the energy system.

In transport, the greatest emission reductions can be achieved by the quick adoption of efficient vehicle technology; this calls for strong policies and measures. The popularity of public transport and pedestrian and bicycle traffic must be increased substantially; this is likely to require both investments in rail systems and economic measures. The development and adoption of sustainable biofuels will also require additional investments.

Sizable reduction of emissions from agriculture is challenging without changes in consumption patterns. Reducing the use of foods that generate a lot of emissions, and replacing them with more environmentally-friendly foods would make it easier to reach the emission targets. Emissions can also be reduced by developing production methods in the whole chain. Increased waste recycling and energy recovery from waste, and a ban on biodegradable waste in landfills, cut emissions from waste management in all scenarios.

Moreover, in some scenarios, emission reduction is facilitated by factors such as:

- change of the economic structure
- reduced transport demand
- carbon capture and storage in energy production and industry
- building of additional nuclear power and its use for district heating
- advance prevention of waste generation

Scenario work to chart long-term low-carbon paths must be continued and developed. It is essential to update the paths regularly, for instance, as the certainty of climate science increases and technology develops. Scenario work strengthens the review of long-term objectives and the measures leading to them; this need was highlighted in the Government's Long-term Climate and Energy Strategy.

Finland would benefit from playing an active role in international cooperation to develop global low-carbon scenarios. Factors affecting the future must be examined broadly – irrespective of whether they are technological and economic, social and cultural, or domestic and international. Besides mitigating climate change, adaptation measures must also be considered. Further efforts call for comprehensive assessment of the role of forests as sources of bioenergy and industrial raw materials and as sinks.

The Government's policies

- The target set is to cut Finland's emissions by at least 80 per cent from the 1990 level by 2050, as part of a wider international effort. In the short and medium term, emissions are cut at a pace that guarantees the attainment of the long-term target.
- Work is continued to develop scenarios for a low-carbon Finland using a participatory approach.
- The scenarios are updated regularly, and the next scenarios will be published during the Government term 2011–2015.
- The updated scenarios will investigate the possibilities of reaching an emissions-neutral Finland by 2050 – i.e. a society that produces no net emissions.
- Effort is made to promote the drafting of global scenarios in accordance with the two-degree target. Assessments are also made on risk scenarios where climate policy does not advance according to the goals.

5 SUSTAINABLE CLIMATE POLICY

Climate protection must support ecologically, socially and economically sustainable development. In fact, many emission reduction measures have important ancillary benefits for society. However, if planned poorly, some measures may also have negative effects. The shift to a low-carbon society requires decoupling, where well-being can be increased at the same time as emissions are radically cut. It may also be necessary to reassess how growth and well-being are defined and measured.

In the classic sense, sustainable development means development that satisfies the needs of the present without compromising the ability of future generations to meet their needs. Thus, the well-being of the present generations must not be built at the expense of the well-being of future generations, for instance by causing irrevocable damage to the environment. Therefore, unmitigated climate change is in sharp conflict with sustainable development.

Sustainable development is often seen to consist of three pillars: ecological, social, and economic. To be truly sustainable, development should take all three dimensions into account, although choices and prioritisations between them cannot completely be avoided.

The sustainability of development must be assessed nationally, as well as globally. As a rule, local environmental loads have diminished in affluent industrialised countries, but at the same time production and environmental damage have moved to rapidly industrialising countries. Locally sustainable development may, in fact, prove to be unsustainable from a global perspective.

Similarly, assessment must pay attention to long-term impacts. A considerable share of the damage resulting from climate change will only be realised during the coming decades, centuries or even millennia. The emission path to be selected must keep the adverse effects of warming within tolerable limits long into the future. For instance, climate change should not lead to the irreversible melting of the Greenland ice sheet – not even during the coming centuries.

Many of the attempts made to solve problems have created new problems elsewhere. For instance, storing food was made easier by developing refrigeration equipment that used freons. However, freons were found to cause depletion of the ozone layer, so they were replaced by compounds that, in turn, greatly accelerate climate change. Lately there has been evidence indicating that some biofuels meant to reduce emissions may in fact accelerate climate change. Simultaneously, the security of food supply and biodiversity are put at risk.

Measures aimed at climate protection can support or hinder sustainable development. Sustainable climate policy must try to identify and prioritise solutions that bring synergy benefits (win-win solutions). For example, promotion of public transport and making energy use more efficient not only reduce greenhouse gas emissions but also bring other social benefits.

Correspondingly, efforts must be made to eliminate measures that both burden the climate and otherwise weaken the preconditions for sustainable development (lose-lose solutions). For example, tax reliefs and subsidies for the use of fossil fuels not only increase greenhouse gas emissions but also cause financial expenses.

Box 5.1 Precautionary principle

The precautionary principle is considered one of the principal guidelines in environmental policy. The classic formulation of the principle dates back to the Rio Declaration in 1992: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

In climate protection, the principle can be illustrated by imagining two extreme alternatives. In the first, humankind reduces emissions to a sustainable level, but subsequent scientific findings show that climate change is less dangerous than had been anticipated. In the second, scientific assessments of the severity of global warming prove to be true, but humankind has not done anything to cut emissions.

In the first alternative, people end up paying a few per cent of their gross domestic product to cut emissions, to no purpose. In the second, humankind is faced with a climate crisis that has potentially catastrophic consequences for people and the environment.

The precautionary principle reminds us that it is better to be safe than sorry. Cutting emissions while there is still some scientific uncertainty is a rational choice.

Ecological sustainability

Besides slowing down climate change, climate policy can have several other positive and negative impacts on the environment and nature. These impacts can pertain to

- biodiversity
- consumption of energy, water, chemicals or raw materials
- air pollution, nutrient loads on water bodies, or soil degradation
- waste or the risk of a major accident
- noise or damage to landscape

Climate change is one of the most important factors underlying the loss of ecosystems and the extinction of species. For this reason, climate protection inherently supports nature conservation. However, depending on the means selected, impacts can also be partly harmful.

When leaves and twigs are collected during the harvesting of forest chips and when tree stumps are pulled up for energy use, the nutrient balance of forests may suffer and the amount of dead wood necessary for threatened species may diminish. Dams may change river environments in ways that threaten the living conditions of species dependent on these environments.

When palm oil and other raw materials suited to food production are used in the production of biofuels, both their demand and prices rise. Even if the cultivation of raw materials for biofuels were certified as sustainable, this increases pressure in other areas to clear forests for cultivation. As a result, the production of biofuels may release many times more carbon dioxide than fossil fuels. The growing demand for food-based raw materials is also reflected in food prices and may aggravate hunger in poor countries.

Cutting atmospheric emissions typically decreases local air pollution. For instance, reduced use of fossil fuels also lowers sulphur dioxide emissions causing acidification.

Increasing the relative share of cars with diesel engines admittedly reduces carbon dioxide emissions, but without separate filters, the amount of fine particulate emissions harmful to health goes up. The consequences are usually the same when light fuel oil is replaced by pellets, wood chips or split logs for heating single-family houses, or when housing is built next to busy roads. A major rise in the use of nuclear power would increase environmental and health risks associated with uranium mining, the amount of radioactive nuclear waste, and the risk of nuclear material ending up in the wrong hands.

Measures that improve the efficiency of energy and raw material use, reduce the transport demand, prevent deforestation, and reduce waste generation are usually the best for producing other environmental and sustainability benefits. Prevention of problems is easier and more economical than addressing their consequences afterwards. For this reason, substantial improvement of eco-efficiency – getting more while burdening the environment less – is ecologically sustainable climate policy.

Social sustainability

The climate is also a question of equity. The first and strongest impacts of global warming are felt in poor countries and among poor people within countries. Hurricane Katrina in the United States and the heat wave in Europe in summer

2003 showed that population groups already in a weaker position, such as old people, children and the poor, are the most vulnerable to extreme weather phenomena even in affluent countries.

The climate also affects equity between generations. Most of the benefits from emission-producing activities are reaped by the present generations, while much of the damage is left to future generations. On the other hand, future generations will also inherit wealth created by means of the emissions.

Climate change can be considered to challenge social sustainability in a fundamental way. Unrestricted warming may shake the foundations of many states. Functional democracy and human rights may then also be in jeopardy.

The positive and negative effects of climate policy are not often distributed evenly. For example, strict emission reductions may create new industrial jobs in sustainable technology, but at the same time they may accelerate structural change and the loss of jobs in the process industry. Advantages and disadvantages must be evened out at the level of the national economy, without abandoning any population group.

Measures to reduce emissions are expected to raise the consumer prices of energy somewhat. The effect on the real costs of households depends on factors such as how much more efficient people's energy use becomes and to what extent the rise in prices can be offset elsewhere.

On average, direct energy expenses, i.e. electricity, heating and fuel costs, account only for about eight per cent of private consumption in Finland. However, price increases affect households in different ways. In the light of consumption surveys, it seems that, in relative terms, a rise in energy prices would have the greatest impact on pensioners, unemployed people and single parents. A rise in energy prices also has indirect effects through higher prices for products and services.

It is possible to reconcile social equity and climate policy. Policies and measures must be systematic and predictable to enable adaptation to changes. The social perspective must be included when climate policy is planned and evaluated. Any rises in energy taxes can be offset for households with the lowest income, for instance, by supporting their investments in energy efficiency, by cutting other taxes or by increasing income transfers.

There are no major conflicts between climate and regional policies either. Most measures to reduce emissions are regionally neutral or their impacts on development between the regions are slight. Climate policy may also support regional policy objectives. It would seem that decentralised energy production based on renewable energy has the greatest impacts. According to a background study conducted for the foresight report, energy production based on biological sources is seen as an important new opportunity to create businesses and jobs, especially in rural areas. It is clear, however, that bioenergy alone is not enough to reverse the direction of regional development. Moreover, it is difficult to estimate the effects of several factors. For instance, higher transport costs may weaken the position of remote areas but, on the other hand, they may encourage local production.

In general, regional policy measures must support the reduction of emissions and adaptation to warming. Conversely, the regional perspective can be strengthened in climate protection measures. For instance, it might be possible to grant an increment to energy efficiency subsidies in the coldest regions. In addition, effort could be made to use regional policy to offset any regional disadvantages caused by climate policy.

The climate and gender

The climate is also linked with equality between genders at least in four ways. Men and women are different with respect to how they

- produce emissions
- suffer from the impacts of global warming
- participate in the formulation of climate policy
- experience the effects of climate protection

According to a Swedish study, men on average produce more emissions than women, for instance because they travel more and account for three quarters of all driving. On the other hand, women on average spend more money on consumer goods. Naturally the variation within the genders is many times wider than between them.

The consequences of climate change affect the genders in different ways, especially in developing countries. In poor countries, women are largely responsible for fetching water and, for instance in Sub-Saharan Africa, they take care of 60–80 per cent of household food production.

Worsening of food and water shortages increases women’s work load, in particular. On the other hand, two thirds of the people who died in France during the hot summer of 2003 were also women, as the heat wave was particularly exhausting for older people.

In international climate negotiations, women have accounted for slightly over one quarter of national delegation members. About 15 per cent of the heads of delegations have been women. Women's participation in climate protection at all stages and at all levels should therefore be strengthened. Women's and men's views of the ways in which climate policy is implemented may also differ.

Box 5.2 Ageing and the climate

Two megatrends of our time – ageing of the population and climate change – are linked to each other. Ageing reduces the share of transport in consumption and strengthens the service-oriented trend in the economy. Especially among older people, the vicinity of services and the need for new types of service housing determines in part where they choose to live; this may support improving cohesion of the urban structure.

It is necessary to take ageing into account when adaptation measures are planned. For instance, preparedness for heat waves, epidemics and floods must be ensured when the population structure is dominated by older people.

Ageing may aggravate the discrepancy between jobs and job-seekers, especially regionally; this may slow down climate protection efforts. In the future, it may become difficult to find enough people to employ, for instance, as operators of forestry equipment or as bus drivers. The availability of labour can be improved through policy measures in labour and education.

Economic sustainability

Most studies estimate that even significant emission reductions are affordable. According to the IPCC, the cost of keeping global warming at about two degrees Celsius would be at most under 3 per cent of world gross domestic product in 2030 and under 5.5 per cent in 2050.

However, regional differences are great. International conventions therefore need mechanisms that prevent the cost burden from reaching unreasonably high levels in any region. Cost estimates also involve major uncertainties.

Three or five per cent of world gross domestic product would undeniably be a major sum. In practice, however, it would mean that economic growth would be slowed down by a year or two. The figure can be proportioned against the cost of the ageing of the Finnish population, which is estimated to be about six per cent of the gross domestic product. In any case, mitigating climate change will be cheaper than not mitigating it.

A study commissioned by the Nordic Council of Ministers has estimated the costs of emission reductions in the Nordic countries. According to the report, a 70 per cent reduction in emissions from the 1990 level would cost one per cent of the gross domestic product in 2050. The International Energy Agency IEA and the consulting firm McKinsey have also estimated the costs of additional investments, and have come up with a figure that is around one per cent. VTT

Technical Research Centre of Finland has estimated that the direct additional costs for cutting emissions in Finland by 60 per cent would at most be 0.6 per cent of the gross domestic product in 2050.

A significant proportion of global emission reductions can be implemented at fairly low or even negative costs. For instance, abolishment of the world's energy subsidies could cut emissions by six per cent while simultaneously accelerating economic growth.

According to the IEA, about one third of the reductions needed to halve the world's energy-based emissions can be achieved through means that also help save money. This can be as much as over one hundred dollars for each tonne of carbon dioxide reduced. On the other hand, the costs of the most expensive tenth of emission reductions could rise to as much as hundreds of dollars per tonne.

Estimates of the impacts of climate policy on the economy and employment depend crucially on the assumptions selected and on the models used in the calculations. For instance, the following factors lower the price of climate protection in cost estimates: use of revenues from energy taxes and from emission allowance auctions to reduce other taxes and to promote innovative technology; and the inclusion of all emission producing sectors, all greenhouse gases and all sinks in the range of measures.

Table 5.1 Effects of various assumptions on estimates concerning the economic impacts of climate protection in 2030

Assumptions	**Effect on world GDP**
The most pessimistic assumptions	*–3.4%*
Use of climate taxes to promote climate protection; revision of the structure of taxation	+1.9%
Application of the general equilibrium model (instead of coarser econometric or growth models)	+1.5%
Reactions of technological development to incentives (induced technological change)	+1.3%
Ancillary benefits (e.g. reduction of air pollution)	+1.0%
Flexible mechanisms	+0.7%
Backstop-technology (unlimited availability of carbon-free energy, such as wind and solar power)	+0.6%
Avoiding the adverse effects of climate change	+0.2%
The most optimistic assumptions	*+3.9%*

Average effect on world gross domestic product in 2030 when the carbon dioxide concentration is limited to 450 ppm (about 500–550 ppm CO_2 equivalent).

Measuring the right things

The principal objective of climate policy is to reduce greenhouse gas emissions. However, emission reductions also have many ancillary impacts, which should be taken into account when policies are planned and monitored. Ancillary benefits may include

- reduction of local air pollution and other environmental damage
- reduced dependence on imports and improved security of energy supply
- diminished energy consumption and lower energy costs
- creation of jobs
- acceleration of innovations

Correspondingly, there may also be ancillary disadvantages

- higher costs
- weaker competitiveness if not all countries agree to participate
- loss of jobs
- risks involved in technological solutions

Estimates of the ancillary benefits of climate protection gained by reducing local air pollution vary depending on the study and circumstances. However, social benefits stemming from the decrease in environmental and health hazards can in some situations cover a reasonable proportion of the costs of emission reductions.

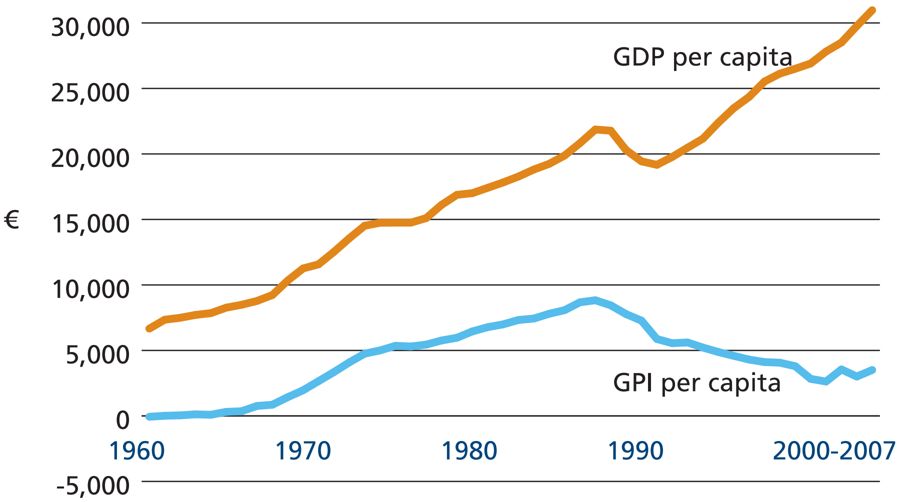
The gross domestic product (GDP) is the most common indicator used to describe an economy's production; it is also used more widely to illustrate individual countries' state of development. One of the GDP's principal shortcomings is that it does not consider the ecological and social costs of economic development.

For instance, clear cutting in a rain forest increases the gross domestic product even though its disadvantages to ecosystem services can be many times greater than the benefit achieved. If the GDP is used as the central indicator measuring the success of a policy, it can lead to the maximisation of short-term monetary benefits even if the overall economic and long-range impacts were clearly negative.

Many new indicators have been proposed to complement GDP data. For instance, the Genuine Progress Indicator (GPI) created by Redefining Progress takes into account the value of factors such as household work and parenting, education and volunteer work. On the other hand, costs also include adverse effects resulting from traffic accidents, crime, pollution, atmospheric emissions, and ozone depletion.

The differences between the indicators are illustrated by the fact that in the United States, the GPI has remained fairly steady in 1950–2000 whereas the GDP has more than doubled. Finland's GPI rose until 1989, after which it has been declining to date. In the 2000s, the GPI has fallen to the level of the early 1970s or even below that.

Figure 5.1 GDP and GPI trends in Finland 1960–2007



Figures per capita at prices in 2000.

Source: Hoffrén, Jukka & Rättö, Hanna : GPI hinnoittelee taloudellisen hyvinvoinnin. [The GPI puts a price on economic well-being.] Tieto&Trendit 2/2009. April 2009. Statistics Finland. p. 47.

Box 5.3 Ecosystem services

Nature has an inherent value but it is also irreplaceably valuable for people in tangible terms. Ecosystem services refer to the various benefits that people gain from natural systems. These include

- provisioning services: food and water
- regulating services: protection from floods, drought and erosion
- supporting services: maintaining the productivity of soils, the nutrient cycle
- cultural services: recreational, spiritual and other immaterial benefits

The demand for ecosystem services increases in parallel with population growth, economic growth and higher material living standards. Climate change is one of the greatest threats to the availability of services, since it is predicted, among other things, to disrupt food supply, to worsen water shortage and to upset the capacity of ecosystems to regenerate.

Ecosystem services have a considerable financial value, an estimated USD 16–54 trillion (thousand billion) per year globally. However, it is highly challenging to give estimates because the data are inadequate and many ecosystem services have no market value equivalent. In some ways it is even impossible to determine a monetary value since these services are the cornerstones of all of human life. Nevertheless, it is better to give a rough quantitative estimate than not to give any estimate at all.

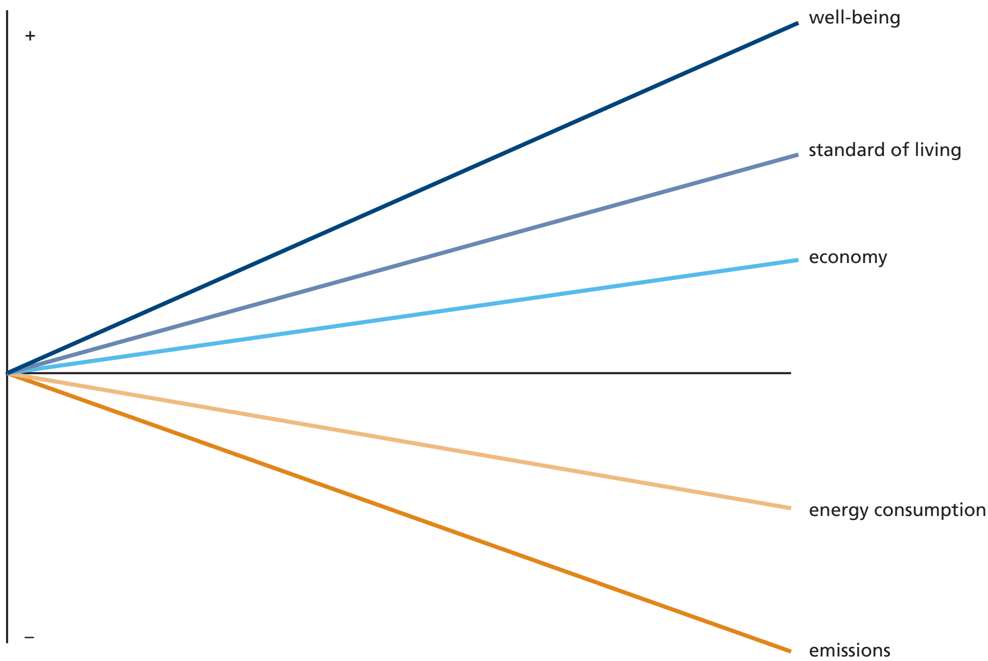
Well-being in a low-carbon society

Environmental policy research uses the term decoupling to describe the breaking of the traditional link between economic growth and environmental degradation. In part, decoupling has succeeded: The carbon intensity of industrialised economies has decreased markedly from the early 1980s.

In Sweden, consumption of electricity has increased by three per cent during the past 15 years, while the GDP per capita has risen by 70 per cent. In California, it has been possible to reduce both energy and electricity consumption per capita to the level that prevailed in the 1960s. In Finland, too, the electricity intensity of the economy has been falling since the early 1990s, but spurred by the volume of the economy, total electricity consumption has continued to rise rapidly.

In responding to the climate challenge, however, weakening of the relative link between the economy and the environmental burden is not enough. What is also needed is absolute decoupling, where social objectives can be reached at the same time as atmospheric emissions are cut dramatically.

Figure 5.2 Decoupling between social objectives and the burden on the climate



As regards the climate, it is desirable to replace material with immaterial consumption. In addition to increasing the material standard of living, our objectives could be improved quality of life and more free time. For instance, it has been estimated that energy consumption could be reduced by one fifth if in 2050 the whole world observed the average European working hours instead of the American ones.

In industrialised societies, climate challenge may be a reason to rethink the priority of objectives. Within the past three decades, Finland's economy and energy consumption have doubled. According to studies, however, the increase in the material standard of living is not much reflected in the happiness Finns' experience. Nevertheless, it must be remembered that, according to many studies, Finns are among the happiest people in Europe, and happiness might have lessened if the economy had not grown.

In a comparative study conducted at the University of Cambridge, differences in happiness between various countries seemed to be explained, for instance, by:

- trust in the State and in other people
- extensive social networks
- a close friend or companion
- work that gives the feeling of self-respect

None of these factors necessarily require a high level of emissions. In contrast, among poor population groups and in poor countries, raising the material standard of living typically increases happiness; in a conventional development model, this is also associated with an increase in atmospheric emissions.

The transition to a low-carbon society may slow down the growth of the economy and the material standard of living. Some of the measures required by a low-carbon society may also be manifested as a slower increase in well-being among the present generations. For example, it seems likely that, owing to climate restrictions, flying and driving based on fossil fuels cannot be as easy and cheap in the future as they are now.

On the other hand, many of the solutions that reduce emissions may increase people's personal well-being. For example:

- if buildings were more energy-efficient than at present, energy costs would fall and the comfort of living would probably rise
- if public transport functioned better than at present, especially people without cars would find it easier to move about, and the time spent by drivers in traffic jams might shorten
- if people walked and cycled more, their state of health would improve and their life expectancy would be longer

- if people's diet contained more vegetables, many health risks would be lower and the life expectancy would be longer

The Government's policies

- Climate policy is assessed from the perspective of sustainable development. The primary means selected are those that are ecologically, socially and economically sustainable.
- Sustainable development is reviewed globally and over the long term. National emissions are not reduced in ways that would increase emissions or hamper sustainable development elsewhere in the world.
- The social perspective is strengthened in the preparation of climate policy. Effort is made to compensate people in the lowest income brackets and the most vulnerable groups for any rise in costs that may result from the emission reduction measures.
- Climate objectives are taken into account in regional policy. The possibilities of linking the regional perspective to emission reduction measures are studied.
- Climate policy is also assessed from the gender perspective. Women's participation in climate policy decision-making in international negotiations is strengthened.
- Assessment of the economic and employment impacts of climate policy is developed and diversified.
- Assessment of the importance of ecosystem services is increased. Effort is made to take the value of the services into account, especially in decision-making that may threaten their availability.
- The indicators of sustainable well-being are developed, tested and applied in order to supplement gross domestic product data.

6 AFFLUENCE WITHOUT BURDENING THE CLIMATE

The economy may prosper in a low-carbon society, too, but its practices need to be fundamentally revised. Technological leaps are needed especially in energy-intensive industries. The climate should be protected without compromising competitiveness. The long-term target should be to reach a completely zero-emission energy system. Radical improvement of energy efficiency and the development and deployment of sustainable technology are key factors in this. At the same time, new sources of revenue and new jobs can be created.

The world is facing a new industrial revolution. In the coming decades, industrialised societies must be rebuilt in a way that facilitates cutting emissions to a fraction of the present level.

This revolution represents both a huge challenge and a huge opportunity. It will require radical change and will also come with a price. On the other hand, it will mean investments, technological leaps and new jobs. There will be winners also in this industrial revolution, and Finland should aim to be one of them.

In the course of the next 40 years, Finland will become a very different place to live and work. These changes form part of a global trend. Substantial investments are being made in education, training and research in most parts of the world, and scientific and technological achievements spread with increasing speed. Revolutionary innovations may emerge at technology interfaces.

In economically developed countries, consumption is geared towards intangible commodities and services. In developing economies, by contrast, growth is still based on material production and consumption, since for the majority of their populations even basic needs remain unsatisfied. Sectoral boundaries are being eroded. It is increasingly difficult to distinguish between products and services; a service can constitute part of a product. Services are likely to become much more international.

The importance of eastern and south-eastern Asia and Brazil in the global economy is expected to continue growing, and Russia's role is also likely to become stronger. New innovation clusters will emerge particularly in locations with strong production growth. Finland's role in the international division of duties may change, but know-how will remain a key competitiveness factor.

Energy, raw materials and water will become more expensive as a result of population growth and economic growth, among other things. There will also be a shortage of arable land. This will force making production processes radically more efficient. Technological breakthroughs and social innovations will be crucial in coping with diminishing natural resources and ever tighter emission limits. In the future, Finland's natural resources may prove to be increasingly important factors for success, if used sustainably.

Where do Finland's emissions come from?

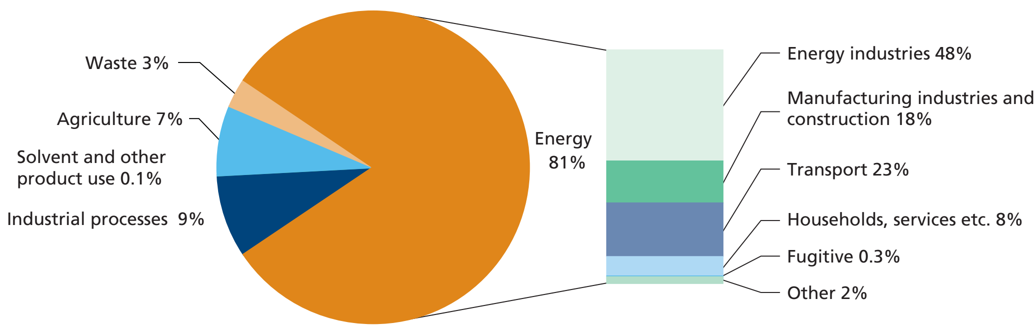
In 2007, Finland produced a total of just under 80 million tonnes of emissions into the air as carbon dioxide equivalents (CO_2-eq). Some 85 per cent of emissions were carbon dioxide, 8 per cent nitrous oxide and 6 per cent methane. Other emissions, such as fluorinated hydrocarbons, or F gases, only account for about one per cent.

On the whole, emissions have increased by 10 per cent since 1990, which is the base year used in international climate negotiations. The growth is attributable to carbon dioxide emissions that have increased by 20 per cent, whereas during the same time nitrous oxide emissions have decreased by 13 per cent and methane emissions have decreased by nearly 30 per cent.

Energy production is the overwhelmingly largest source of emissions in Finland, accounting for about two thirds of them. This load consists of carbon dioxide from the combustion of coal, oil, natural gas and peat. Emissions have increased as energy consumption has grown.

The second most important source of emissions is transport, which accounts for just under 20 per cent of all emissions. Industrial processes and the F gases used in industry cause about 9 per cent of Finland's emissions; agriculture produces 7 per cent and waste management 3 per cent.

Figure 6.1 Finland's greenhouse gas emissions by sector in 2007



Excluding land use, land use change and forestry.

Source: Statistics Finland. 2009. Greenhouse gas inventory.

Forest growth in Finland sequesters more carbon dioxide than forest felling releases into the atmosphere. In the period 1990–2007, the amount of carbon dioxide bound by Finland's forests annually amounted to between 30 and 55 per cent of the emissions caused by other sectors. On the other hand, emissions from agriculture, peat production and forest clearing are a burden on Finland's carbon balance.

By the middle of this century, the sources and distribution of Finland's emissions will look very different compared to the present. Various possible ways of achieving the transition to a low-carbon society are outlined in the scenarios described in an appendix to this report. On the basis of the current emissions distribution, the greatest climate benefits in reducing emissions in Finland can be achieved with the following:

1. energy efficiency in the use of electricity and heating
2. renewable and zero-emission energy sources
3. energy efficient vehicles and low-emission energy sources
4. reducing the transport demand and introducing sustainable forms of transport
5. introducing low-emission solutions into industrial processes and
6. shifting food production and consumption towards low-emission options

A strong, low-emission industrial sector

Finland's economic structure is dominated by industry. Although industry's share in the economy has grown smaller, it still produces some two fifths of the GDP and employs about one fifth of the workforce. If the service jobs that directly or indirectly depend on the industrial sector are included, industry is even more important to the national economy and to employment.

Part of Finland's industry is highly energy-intensive. The largest consumers of energy are the forest industry and the metal refining industry. In all, industry consumes half of Finland's energy. Goods transports account for a substantial amount of fuel consumption.

Iron and steel production generates large amounts of carbon dioxide, and nitric acid production generates nitrous oxide. Process emissions have increased by one fifth since 1990. At the same time, however, production has become more efficient: Specific emissions from steel production, for instance, have decreased by more than 20 per cent.

Many of Finland's industrial processes are quite energy-efficient and low in emissions by international comparison. According to industry's own estimates, Finland's emissions per tonne of steel produced may only be about half of the European average when emissions from the mining industry are included. In zinc production, the differences in energy consumption between facilities may be even greater.

If the products will be produced anyway, they should be produced as efficiently as possible to protect the climate. It will be important for the Finnish national economy to retain a strong manufacturing industry also in the future.

However, process industry can only prosper through reform. Rising energy prices, tightening emissions caps and increasing production from emerging economies force the industrial sector to use energy and raw materials more efficiently and to cut emissions. Technological leaps and emission-free energy are needed in industry.

Finland produces and refines steel, copper, zinc and nickel. Emission reductions represent the greatest challenge for those metal refining applications that are dependent on purchased energy and produce substantial process emissions.

Emissions from metal production can be reduced by improving energy efficiency, by increasing the use of recycled raw materials, by replacing fossil fuels with renewables and by using zero-emission electricity. Replacing carbon-intensive metals with materials causing fewer emissions will also reduce the emissions total.

In the long term, however, radical innovations are needed that will enable both increased production and reduced overall emissions. The international ULCOS project in the steel industry is seeking ways to halve specific emissions by carbon capture and storage, electrolysis using emission-free electricity production, and the replacement of coal with charcoal.

The chemical industry accounts for one fifth of all industrial energy consumption. Its emissions can be reduced, for instance, by employing more efficient processes, making better use of heat recovery and applying industrial biotechnology.

Concrete production is one of the most emission-intensive areas of industrial production; it generates almost as much greenhouse gas emissions as it produces finished product. The emissions can be reduced, for instance, by adding industrial by-products to concrete mixes, by improving plant efficiency and by fuel switching. Overall, the realistic emissions reduction potential in Finnish concrete production is about one per cent of the country’s total. In the long term, principal means may involve replacing concrete with less carbon-intensive construction materials and employing carbon capture and storage.

Forest industry and transport

In 2007, the forest industry accounted for just under three fifths of all industrial electricity and energy consumption in Finland. Half of this energy was produced using wood fuels. The most heat-intensive processes are the evaporation, drying and cooking processes, while electricity is consumed most in the production of groundwood pulp and in pumping. Fossil fuels are also directly used in industrial processes.

It is estimated that even with existing technology, it is possible to improve the energy efficiency of the forest industry by about 20 per cent in new mills and 30 per cent in old mills. Energy use can be made more efficient, for instance, by using frequency converters on electrical motors and by increasing the use of recycled fibre. The net energy yield can be increased by drying fuels, by black liquor gasification, by increasing the power-to-heat ratio (i.e. increasing the percentage of electricity in the energy) and by using residual heat from processes for district heating for communities. Moreover, fossil fuels and peat can be replaced with wood biomass or arable biomass, and emission-free alternatives can be sought in purchased electricity.

In Finland, radical new energy-efficient and material-efficient solutions for the forest industry are being sought by Forest Cluster Ltd., a joint venture of companies and research institutes. There is future promise in the area of biorefineries, which are integrated facilities that use biomass to produce paper, energy, biofuels, chemicals and biomaterials. This will enable the creation of new products and replacement of the use of non-renewable natural resources.

About one fourth of transport emissions is generated by vans and lorries. In many cases, transport emissions can be reduced by 10 to 20 per cent simply by rationalising the logistics. The International Energy Agency (IEA) estimates that it is possible to improve energy efficiency through technological means by at least 30 per cent at moderate cost by the year 2050. Additional investments in vehicle technology development could yield even greater energy efficiency improvements. Energy efficiency can be improved for example by extending the emission-related differentiation of taxation (currently applied to cars and vans) to heavy duty vehicles.

Typically, specific emissions from rail transport and shipping are considerably lower. Moving transport from the roads to rail transport and shipping is attractive particularly over long distances and when transporting heavy loads, such as vehicles or large quantities of wood. This calls for investments in economically and ecologically sustainable rail transport and shipping projects.

Alternatives for fossil fuels must also be sought in road transport. For heavy traffic, changing to completely electrically powered vehicles seems technologically challenging at the moment, but hybrid technologies could help reduce fuel consumption in delivery traffic in urban areas, for instance. Natural gas and sustainable biofuels could begin to partly replace oil in the short and medium term, and green hydrogen in the long term.

Carbon leakage and wind leakage

The term ‘carbon leakage’ is generally used to refer to the threat of emissions restrictions causing industrial production to relocate to countries where such restrictions do not exist. This would undermine the economy and employment in the countries that impose emissions restrictions. As the relocated production capacity would take its emissions with it, and as production is more carbon-intensive in some countries without restrictions, the carbon leakage would probably also be harmful to the climate. The same mechanism also applies, in principle, to food production.

There are three main mechanisms causing carbon leakage:

1. competitiveness: emissions restrictions increase the price of emission-intensive products, which may cause production subject to restrictions to lose market share to production operating outside restrictions
2 investments: emissions restrictions may encourage investments in countries outside the restrictions if this will bring a better return
3 the price of energy: decreased demand for energy due to emissions restrictions lowers the price of energy, which may increase the demand for energy elsewhere, and hence emissions

The threat of carbon leakage varies significantly from one sector to another, and even within sectors. For most service businesses, and even for many industrial companies, the price of energy and emission rights is a negligible cost in the big picture. Even in energy-intensive industries, climate and energy costs are not the only factors; the location of production is also influenced by proximity to markets, availability of competent labour and the cost of labour and raw materials.

What is essential in terms of carbon leakage is how far businesses can pass on the costs of emissions restrictions to product prices. The easier it is to pass the costs on to the customer, the lower the threat of carbon leakage is. The ability to pass costs on to prices varies according to a number of factors, including how open the sector is to international competition. Because Finland’s economic structure relies heavily on exports and emission-intensive industries, this is an issue of more than average importance, and the threat of carbon leakage must be taken seriously.

The IPCC has estimated that as a result of the Kyoto Protocol, carbon leakage could amount to between 5 and 20 per cent of emission reductions by 2010. According to a study published by the IEA, the first emissions trading period of the EU has not been found to cause carbon leakage in any of the sectors that were considered vulnerable. According to the OECD, on the other hand, carbon leakage would amount to slightly over one per cent of the emission reductions achieved if all industrialised countries were to reduce their emissions to half of the 2005 level by 2050.

In terms of climate protection, carbon leakage may be partly compensated by its opposite, a phenomenon sometimes called 'wind leakage'. This means that emissions restrictions may stimulate emission reductions in countries outside those restrictions, too.

There are several mechanisms that may generate climate benefits outside countries that have imposed emissions restrictions. Even if limited in geographical coverage, emissions restrictions

- lower the price of sustainable technology
- create markets for sustainable technology suppliers and encourage other countries to utilise sustainable solutions
- create investment security and encourage investors to make extensive, long-term investments in sustainable technology
- encourage politicians and public opinion by example to be favourable to climate protection,
- create political pressure by demonstrating that some countries are willing to commit themselves to the efforts to protect the climate
- generate and disseminate climate policy know-how

Reconciling climate protection and competitiveness

The most sustainable way of combating the threat of carbon leakage is to achieve an international solution where binding emissions restrictions cover as large a share as possible of the world's emission-generating industrial production. As far as the Finnish forest and metal industries are concerned, it would be important that major countries currently not imposing restrictions, not only the USA but China in particular, get on board. This would ensure that businesses had as level a playing field as possible regardless of where they are located.

But however comprehensive an agreement may be, it will not necessarily remove the competitiveness threat altogether; it is hardly politically realistic to impose similar costs on production in emerging economies as on businesses in industrialised countries. This imbalance may be corrected by augmenting national emission targets with sector-specific obligations for the most emission-intensive industries.

Competitiveness disadvantages can be combated through measures at the EU and national levels. Companies in the most vulnerable industries are granted emission rights for free in the EU emissions trading system, thus postponing the transition to an auction of emission rights. Direct subsidies are also possible.

One of the options discussed in the EU is border protection on foreign trade, or what is known as border tax adjustments for products from countries opting out of the emissions restrictions. Such tax adjustments involve several legal and trade policy challenges and thus cannot be regarded as a primary instrument. Their application should be explored, however, in order to have them as an available measure in case a sufficiently large group of key countries does not participate in emissions reductions.

The costs of both emission reduction methods and relevant policies and measures vary substantially. While attaining a specific emission reduction target at a moderate cost is possible, very high costs may also occur. Maximising cost efficiency in climate policy may be a way to respond to competitiveness concerns.

The climate benefits of emissions restrictions in non-restricting countries can be maximised in a number of ways. The restrictions must apply to a market area as broad as possible in order to create sufficient demand for sustainable technology and strong political pressure. Undue commitment to individual technological solutions must be avoided, and the rest of the world must be given the opportunity to benefit from becoming suppliers of sustainable technology. Restrictions should also be linked to extensive international cooperation, for instance by supporting poor countries in their climate protection efforts.

Involving services in the climate protection effort

Services have steadily become increasingly important for the Finnish economy and are expected to grow in importance. Today, almost two thirds of all value added is generated by services, which also provide more than two thirds of all jobs. The most important private service sectors are trade and business-to-business services. Many Finns are also employed in tourism, restaurants and cafés, and telecommunications services.

Services as a whole consume some 30 TWh of energy per year. Private services are estimated to account for about 20 TWh of this. The emission intensity of services, calculated over their life cycle, is on average less than half of that of industrial production. Industry generates just over one kilogram in emissions (CO_2-eq) per 1 euro of the end product's value, while the figure for services is 0.5 kg.

However, because of their large volume, services already account for about 30 per cent of all emissions in Finland. The largest service sectors already produce as much emissions as traditional industrial sectors. Retail and wholesale trade, for instance, cause emissions on a par with those of the pulp and paper industry, while health care services equal the emissions of the basic chemical industry.

The importance of services as producers of emissions is continuing to increase. For example, electricity consumption in the service sector has increased by 3 per cent per year in the 2000s. Without further action, energy consumption is anticipated to grow by up to a third from the present level. Also, the emission reduction potential has been addressed in services to a lesser extent than in industry.

Some 60 per cent of the emissions from the service sector come from housing, trade, public administration, health care and training services. Lighting accounts for more than one third of the electricity consumption in the service sector while heating, plumbing and air conditioning cover just under one third. Refrigeration and office equipment account for about 7 per cent each, and other devices for the rest.

According to estimates, the energy intensity of services could, in principle, be reduced by up to 25 per cent by 2020 and by 70 per cent by 2050. The realistic reduction potential is estimated to be 10 per cent by 2020 and 50 per cent by 2050.

Even the provision of online services produces emissions. According to an estimate by the Global e-Sustainability Initiative (GeSI), the information and communication technology (ICT) sector as a whole accounts for 2 per cent of the world's carbon dioxide emissions, and this is expected to increase to 4 per cent by 2020. Emissions can be reduced, for instance, by using servers and computers more efficiently, by choosing energy-efficient devices and by recycling devices and thus extending their useful life.

However, ICT is part of the solution rather than part of the problem, since on the whole it has potential for helping reduce emissions in all areas of society. Information society services such as e-billing and e-commerce, teleworking and videoconferencing can replace many emission-producing actions. For example, transport demand can be reduced by managing an increasing number of transactions as e-transactions. ICT can help make buildings, energy networks, production processes and transport systems smarter and hence more energy-efficient. According to GeSI, ICT could help reduce emissions worldwide by up to 15 per cent by 2020.

Being a country whose strengths include ICT, Finland is excellently placed to benefit from the potential of information society services in reducing emissions and generating export revenue. Accordingly, information society developments need to be boosted, and the actual potential of ICT in contributing to emission reductions should be explored in all sectors.

Retail trade produces more than one million tonnes of carbon dioxide per year and consumes just over 1 per cent of the electricity and heat generated in Finland. Emissions can be best reduced in the trade sector by using renewable energy and by enhancing energy use, for instance through heat recovery, energy-efficient lighting and improved efficiency of cold storage. Trade can also rationalise goods transports, prevent waste generation and recycle waste.

Two fifths of emissions produced in global tourism are attributable to flying, one third to motoring and one fifth to accommodation. In the tourism and catering sector, emissions can be reduced for instance by promoting local tourism and low-emission transport options, improving the energy efficiency of buildings, using green electricity and enhancing logistics. Climate-friendly options can also be offered to customers in restaurants.

SMEs and the public sector

Small and medium-sized enterprises are of great importance to Finland's economy and employment. More than 99 per cent of the businesses in Finland are SMEs, and collectively they account for half of the turnover of all businesses.

SMEs have their own strengths in climate protection. For example, a major portion of the renewable energy potential depends on local or regional SMEs. In a sustainable urban structure, SMEs play an important role as providers of local services. Moreover, many sustainable innovations have been discovered in SMEs.

On the other hand, SMEs face certain challenges in reducing their climate load. Businesses are often not sufficiently aware of the environmental impact of their operations and do not have the expertise or the resources to manage their environmental obligations. SMEs must be offered sector-specific guidance concerning their potential to reduce emissions. The Energy Efficiency Committee of the Ministry of Employment and the Economy has proposed an energy conservation voucher to promote energy efficiency measures in SMEs.

The public sector accounts for a relatively high percentage of Finland's climate load. Central and local government buildings use 15 TWh of energy annually, producing an estimated 4 to 5 million tonnes of emissions.

There is considerable potential for increasing efficiency in public services and administration. For instance, incandescent light bulbs have accounted for one fifth of all lighting procurement, even though alternatives that are more energy-efficient and cheaper overall have been available for quite some time.

Means for reducing emissions in the public sector include:

- procuring more energy-efficient equipment (e.g. replacing desktop computers with laptops and procuring kitchen appliances with energy classification A+ or A++)
- using equipment more sensibly (e.g. switching computers off for the night)
- planning and using lighting more efficiently (e.g. LED lights, motion sensors)
- improving energy efficiency in buildings (e.g. insulation, heat recovery, window replacement, ventilation adjustment)
- cutting energy consumption in transport (e.g. procurement of low-emission vehicles, training in eco-driving)
- switching to renewable energy

Energy consumption in the public sector can also be reduced by more efficient use of facilities, which can cut the demand for energy for heating. The Ministry of Finance estimates that this productivity potential is 10 to 50 per cent, depending on the administrative sector and function. For example, the North Karelia University of Applied Sciences managed to enhance its use of facilities by 25 per cent.

Agriculture and forestry

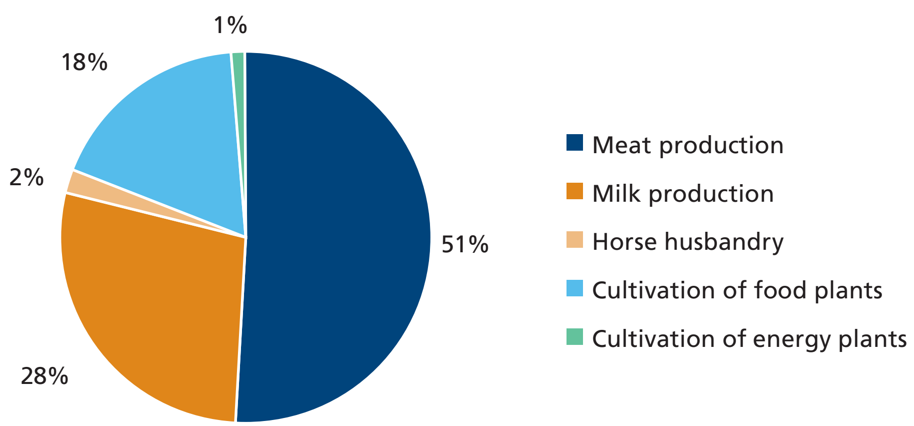
The share of primary production in Finland's economic structure has been declining for a long time. Climate change and increasing competition for natural resources may slow down this decline or even reverse it in the future. Finland must be prepared to increase agricultural production if this is necessary in terms of contributing to the food supply globally. Forests and minerals may also increase in importance.

The Government emphasises that Finland will continue to produce agricultural products in volumes that are sufficient to cover at least domestic consumption. Preparations for the Foresight Report on Climate and Energy Policy have only tentatively addressed issues relating to the future and security of supply of Finnish agricultural production. The prospects of domestic food production will be discussed in the Government's food strategy extending until the year 2020.

Climate change will most likely affect conditions for cultivation adversely in many of the world's current principal production areas. In Finland, by contrast, global warming is anticipated to increase crop yields. On the other hand, the increasing incidence of extreme weather events, plant diseases and pests may offset some of this production growth.

For primary production to thrive, it must be prepared to reinvent itself to adapt to changing circumstances. Preparedness for climate change risks is needed in agriculture and forestry. New plant varieties and procedures are needed to maximise benefits. As the prices of artificial fertilisers and energy rise, the conditions for organic and local foods will probably improve. Increasing the use of natural fertilisers can help reduce the use of artificial fertilisers and utilise waste management side flows.

Figure 6.2 Agricultural emissions by production line



The percentages are based on estimates and are therefore indicative.

Source: Bionova Engineering. 2008. Maatalouden kasvihuonekaasupäästöjen kustannustehokas vähentäminen [Cost-efficient reduction of agricultural greenhouse gas emissions]. Report by the Ministry of Agriculture and Forestry, 26 April 2008, p. 22.

There is still a lot of uncertainty regarding the effects of crop cultivation on the carbon balance of the soil. More research is needed on emissions from land use and agriculture and on efficient ways of reducing emissions. Climate protection measures must also be planned so that they do not jeopardise the Finnish agriculture or global food security.

Between 1990–2006, greenhouse gas emissions from agriculture decreased by more than 10 per cent in the EU and by some 20 per cent in Finland. Agricultural support policies have encouraged production that causes fewer emissions than before.

Research findings so far suggest that agricultural emissions can be reduced, for instance, by developing cultivation methods and techniques, by changing animal feeding methods, by giving guidance on cultivation measures, especially in organic soils, and by adopting more efficient manure processing methods. For example, grassland farming in peat fields is already promoted by means of environmental subsidies. In addition, replacing animal products with plant-based products as applicable would help reduce emissions.

Agriculture remains almost completely dependent on imported fossil-fuel energy even today, although notable renewable energy potential exists on farms. A study conducted at the University of Jyväskylä shows that farms could become energy self-sufficient by the 2020s through the use of biogas, forest and arable energy, solar energy and wind power. Thereafter, farms could produce renewable energy for the rest of society, too. The energy efficiency of cattle sheds, greenhouses and farm machinery can be substantially improved.

Finnish agriculture is also dependent on imported animal feed. Self-sufficiency in plant proteins for animal feeds is only about 15 to 30 per cent, depending on how it is calculated. Concerns regarding deforestation of rain forests have been voiced in connection with the cultivation of soy, which is used for animal feed. Imported animal feed can partly be replaced with by-products from local biofuel production. The use of nitrogen-binding legumes in animal feed production would also help reduce the need for fertilisers.

Biotechnology has prompted lively public debate. If its risks are sufficiently managed, it has significant climate protection potential. In the future, it may be possible to use biotechnology, for example
- to improve crop yields and energy content of energy crops
- to facilitate the use of cellulose-based biofuels
- to reduce the use of fertilisers
- to develop plant varieties better suited for no-till farming
- to produce animal feed that can reduce emissions from livestock

Forests and other natural carbon stocks

Forests, peatlands, soils and seas have sequestered a considerable percentage of the carbon that humankind has released into the atmosphere. These natural carbon-binding processes are called carbon sinks. The carbon stocks created by these sinks can be maintained and increased in many ways.

Managing carbon stocks yields many benefits. For example, the world's forests and peatlands regulate local climates and hydrology, prevent erosion, sustain biodiversity and provide local inhabitants with food and also with income through tourism and other businesses.

In Finland, the carbon stocks of commercial forests can be further increased through forest management, for example by extending the rotation period, by increasing the density of cultivation and by switching to structurally diverse forests. Afforestation and restrictions on forest clearing increase the volume of standing timber, and clearing the backlog in management helps accelerate growth.

Protected forests are carbon sinks, too. In young protected forests, carbon is bound to the growing tree stock at a high rate. Old-growth forests can for a long time, for example through decaying wood, continue to bind more carbon than they release.

Biomass products, which can be used to replace carbon-intensive raw materials, for instance in construction, also bind carbon for relatively long periods of time. The Finnish Forest Research Institute (Metla) estimates that some 100 million tonnes of carbon dioxide are temporarily sequestered in wood products in Finland. In agriculture, no-till farming and perennials can in some areas help increase carbon stocks in the soil.

Finland's largest carbon stocks are contained in peatlands. The carbon balance of peatlands could in some cases be improved by reducing ditch cleaning and supplementary ditching and by abandoning first-time ditching. Peat extraction should, as per national land use guidelines, be concentrated on peatlands that are already drained or that are otherwise no longer in their natural state, where the dried surface peat has begun to decompose. Used drainage areas can also be afforested.

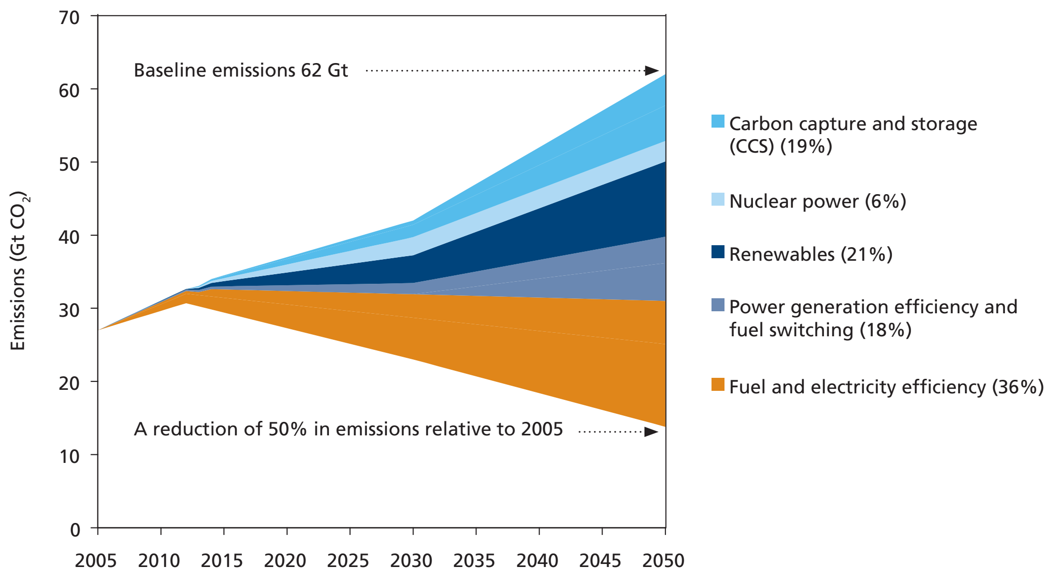
In this sector, too, policy objectives must be harmonised. Increasing the use of bioenergy must not be allowed to threaten the carbon stocks of forests; and on the other hand, increasing carbon stocks must not compromise local residents' food supply. The impact of collecting felling waste and tree stumps on the nutrient balance and range of species in forests at the national level must be studied. Bioenergy use must be based on carefully planned sustainability criteria.

Increasing carbon stocks is an important measure on low-emission paths. However, research shows that global warming can turn some carbon sinks in forests and soil into carbon sources, which in turn could significantly intensify climate change. For instance, in Finland carbon emissions from forest soils could increase by a factor of 1.5 to 2 should local climate warm up by four degrees Celsius. The impact of climate change on the greenhouse gas balance of ecosystems must be taken into account, and climate protection cannot be based on carbon sinks and stocks in the long term.

Towards more efficient use of energy

The less energy we need, the less we need to produce it in ways harmful to the climate. On the other hand, the more efficiently we use energy, the greater share of our energy needs can be met using zero-emission and renewable sources. All forms of energy have their disadvantages, and the best way to minimise these is to use as little energy as possible. The scenarios of the foresight report indicate that achieving a low-carbon society requires radical improvement in energy efficiency in all sectors and at all levels of society.
International research demonstrates consistently that improving energy efficiency and conserving energy are the most important and inexpensive ways of reducing emissions. According to the IEA, more than half of the emission reductions required in the energy sector worldwide can be achieved by improving efficiency. In fact, for a substantial percentage of efficiency investments, the cost impact is negative: reducing emissions saves money. Recent domestic studies show that in Finland, too, the costs of energy efficiency measures are recouped more quickly than anticipated.

Figure 6.3 Halving energy production emissions worldwide in various ways



Based on Energy Technology Perspectives 2008. Scenarios & Strategies to 2050. OECD/ International Energy Agency 2008, p. 64.

In some cases, reducing the overall consumption of energy may mean an increase in the consumption of electricity. For instance, replacing petrol and diesel cars with electric cars and oil heating with heat pumps may decrease the consumption of primary energy and related emissions, but, at the same time, the demand for electricity will increase. Such growth in electricity consumption can be compensated with more efficient electricity use elsewhere.

The EU emissions trading has changed the role of energy efficiency. The trading system essentially guarantees the attainment of emission targets in the sectors which it covers. But even with the emissions trading system, improving energy efficiency is essential for a number of reasons:

- cost: because the most cost-effective emission reductions are typically achieved through energy efficiency measures, implementing these measures lowers the overall costs of climate protection
- ambition: by making emission reductions easier through energy efficiency, tighter emission targets can be adopted in the future
- domestic benefits: the benefits of energy efficiency measures – employment, improved energy security and lower energy costs – remain in Finland
- innovation: investing in energy efficiency stimulates technology development and thus helps decrease future emission reduction costs
- coverage: in sectors not covered by the emissions trading system, improving energy efficiency translates directly into emission reductions

Obstacles to energy efficiency must be removed

Although improving energy efficiency is in many cases profitable, investments in efficiency often remain unmade. There are several obstacles:

- unawareness of the potential
- negative attitudes
- lack of expertise
- lack of services and markets
- lack of strong political support
- lack of capital
- disparity of solutions

In many businesses, the need to concentrate capital into production investments hinders the improvement of energy efficiency. An unreasonably short repayment period is expected on efficiency investments. One option would be to give businesses the opportunity of depreciating energy efficiency investments in their accounts and taxation immediately, during the year in which the investment is made. Such investments would cut energy costs and improve the competitiveness of businesses. An alternative might be a partial energy tax refund for businesses that have implemented verified energy conservation measures. Energy service companies (ESCOs) can also help implement efficiency investments.

Some countries employ 'white certificates' to promote energy efficiency. In this system, operators on the market are required to achieve a certain level of energy savings. They can either implement the savings themselves or buy certificates of savings undertaken by other parties.

Citizens often lack the know-how to implement energy-efficient solutions. Guidance and energy efficiency services are needed. The Environment Committee of Finland's Parliament has proposed that households be offered energy reviews free of charge. Planning and implementation of energy efficiency measures should also be easily accessible to citizens.

Several studies indicate that there is still plenty of cost-effective potential for improving energy efficiency in Finland. The Energy Efficiency Committee appointed by the Ministry of Employment and the Economy has identified measures that would reduce the final energy use by 37 TWh by 2020, of which 5 TWh would be electricity. The potential is a function of price, technology and policy: The efficiency potential increases as the price of energy rises, technology develops and policies and measures are strengthened.

Table 6.1 Examples of energy efficiency potential by sector

Sector	Means	Potential
Heating buildings	Energy efficiency standards, renovation subsidies, publicity and training, ensuring financing for builders	13.9 TWh in 2020 33.7 TWh in 2050
Household electricity consumption	More efficient devices, real-time electricity consumption metering	2.3 TWh in 2020 4.7 TWh in 2050
Services	More efficient devices, support for structural development in the sector, improving the functionality of processes	3.8 TWh in 2020 12.6 TWh in 2050
Pulp and paper industry	Process optimisation, more efficient equipment, new technologies (including lowering the volume of traditional products but not the consumption of new products)	4 TWh in 2020 13.5 TWh in 2050

The Energy Efficiency Committee has identified a set of essential cross-cutting factors of energy efficiency which they have termed the 'foundation for energy efficiency'. These include

- a learning and developing society
- values, will and determination
- sustainable basic structures of communities
- behaviour, networks and social potential
- a life-cycle approach and cost-efficiency, no partial optimisation

- expertise, training, guidance and awareness-raising
- the science-research-development-innovation chain
- continuity of operations, systematic implementation and clear responsibilities
- follow-up, concepts and indicators
- foresight and identification of weak signals

Better balance between consumption and production

In electricity consumption, what is important is not only the overall consumption but also its timing. The additional electricity for peak demand is largely produced inefficiently as condensing power, using fossil fuels and peat, when the emissions per unit of energy area at their highest. During peak demand, one kWh of electricity can produce a climate load four times larger than the average. Therefore, it makes sense to try to even out peak demand.

In the process industries, production is already subject to flexible adjustments according to the price of electricity. The national electricity transmission system operator, Fingrid, has agreements with industry whereby it can disconnect 500 MW of power load, which can be shed or transferred for use at another time. There is a further demand response potential of 500 MW available in industry, and 300 MW for electric heating.

In the future, 'smart electricity grids' will enable better demand response. Households could have access to real-time information on electricity consumption and be advised, for instance, to shift activities such as running washing machines outside of peak hours. Some devices such as electric storage heating equipment could time their operations automatically so as to avoid peak loads.

Adopting electric cars will add flexibility: Car batteries can be charged when there is plenty of electricity available, and they can discharge back into the grid when there is a shortage. More efficient and cheaper technologies for storing electricity can also help even out supply and demand in the future.

Extensive demand response for small businesses and households will only be possible if consumption can be monitored in real time using remote metering. At least four fifths of all small users' electricity meters must be remotely readable by 2013. Pricing that gives incentives to use electricity outside peak hours must be promoted on the market.

Towards a zero-emission energy system

Electricity production accounts for about one fifth of Finland's total emissions and heat production for over one fourth. In 2006, coal accounted for nearly one fourth, natural gas for one tenth and peat for one eighth of Finland's total emissions. Oil products accounted for nearly one third, but the majority of this came from transport.

Energy production is in a key position in efforts to achieve a low-carbon society, both because of the high share of emissions it produces and because of its substantial emission reduction potential. The scenario review in the report shows that radical emission cuts may be highly challenging and expensive to achieve in many sectors, such as air traffic, agriculture or industrial processes. Indeed, it is justifiable to require reductions greater than the national average in the energy sector in order to allow leeway for other sectors.

The interim target must be an energy system with substantially lower emissions than at present, and then ultimately a completely emission-free energy system. This requires the gradual reduction and eventual discontinuation of forms of energy production causing greenhouse gas emissions. The scenarios in the report indicate that this can be achieved. However, removing obstacles from carbon capture and storage may offer potential to continue using fossil fuels and peat in energy production to some extent in the future; but building new fossil-fuel power plants without carbon capture and storage would lead into a carbon lock-in pathway and complicate achieving a low-emission energy system.

Emissions from energy production can be reduced in five different ways:
1. by improving the efficiency of energy production and transmission
2. by replacing high-emission fuels with low-emission fuels
3. by increasing the share of renewable energy
4. by adopting carbon capture and storage
5. by replacing emission-causing energy production with nuclear power

The efficiency of energy production can be improved by raising the efficiency of boilers. The efficiency of the old condensing power production is less than 40 per cent. According to VTT Technical Research Centre of Finland, solid-fuel condensing power plants could achieve an efficiency of 60 per cent by 2030. Gasification technologies can improve the power-to-heat ratio in combined heat and power production (CHP) while raising efficiency close to 90 per cent.

In heat production, efficiency can be improved by making better use of the heat in flue gases. By using residual heat to dry the biomass produced as an industrial by-product before burning it, several TWh of additional energy could be produced per year.

Energy production can also be improved by introducing combined heat and power production to small district heating plants run by local authorities and businesses

(1 to 100 MW). The technology is available for CHP at an even smaller scale, but estimates vary as to its profitability in such cases. According to VTT, even power plants with an output as low as 1 kW could be profitable in the 2030s.

At the moment, power losses in the distribution of electricity amount to about 4 per cent of electricity consumption. Efficiency of distribution can be improved by adopting best technologies involving the placement, rating and efficient use of transformers, choice of cabling and avoidance of excess voltage.

An emission-free energy system will include more widespread use of decentralised energy production making use of local renewable energy sources. Solar energy, wind power and combined heat and power production using biomass can be applied in single buildings or even single households. Decentralisation brings production close to consumers, which decreases the sensitivity of the system to widespread disruption and cuts down on power loss in transmission.

In some countries, net metering of electricity has been introduced to promote small-scale electricity production. In California, for example, electricity consumed is added to the utility bill as usual, but if a building generates its own electricity and feeds surplus into the grid, this is deducted from the bill. The customer only pays for the net electricity consumed per year; though on the other hand, the power company is not obliged to purchase the surplus that a building may produce. In the future, Finland may also have small-scale electricity production by households and businesses using wind power, solar energy and biofuels covering perhaps more than 10 per cent of the total nationwide consumption.

Box 6.1 A pan-European supergrid

One of the elements mentioned in connection with sustainable energy systems is what is known as a supergrid. A supergrid would link electricity markets over wide geographical areas and would help optimise variable electricity production. High Voltage Direct Current (HVDC) technology enables the transmission of electricity over distances of thousands of kilometres with minimal power loss.

A supergrid would enable centralised production of renewable electricity at locations where it is cheapest to do so, for use where the need is greatest. In Europe, a supergrid could link solar energy production in northern Africa with wind power production on the Atlantic seaboard. Hydropower produced in Norway and in the Alps could be used to even out the fluctuations in wind and solar power.

A pan-European supergrid would be administratively arduous and financially expensive to build. It would, however, enable a greater share of renewable energy and at a lower cost compared to the situation in which each country would try to increase its renewable energy production on its own.

Renewable energy brings substantial benefits

In Finland, renewable energy accounts for 28.5 per cent of end use, one of the highest percentages in the industrialised countries. Of this, about two thirds comes from bioenergy produced as a by-product of the forest industry and a little over 10 per cent from hydropower. New renewable sources such as wind power and heat pumps account altogether for 0.2 per cent. The National Climate and Energy Strategy of the Finnish Government aims at increasing the percentage of renewable energy to 38 per cent by 2020 and to 60 per cent by 2050.

There is considerable renewable energy potential in Finland. In the short term, the greatest increase can come from the use of forest and arable energy outside of industrial sectors, from biogas and from heat pumps. Solar collectors can be used to help heat detached houses. Hydropower construction may also help, if it can be undertaken in a sustainable way without endangering natural and recreation values.

In the medium and long term, the greatest potential is in wind power. In Finland, there are wind farm projects being planned or investigated that together total more than 5,000 MW of capacity. The technological potential is many times greater, and the largest limitations in the long term have to do with how to connect the wind power capacity to the national grid.

Denmark already produces about one fifth of its electricity using wind power. The Irish government intends to increase the percentage of renewable sources in electricity production to one third by 2020, most of the increase coming from wind power. In Finland, the integration of large amounts of wind power capacity into the energy system is facilitated by Finland's participation in the Nordic electricity market and the fairly high percentage of hydropower in the system.

In the longer term, even newer forms of renewable energy may be adopted in Finland. Thin-film solar cells are both thin and flexible. As the efficiency of solar cells improves and as they become more affordable, solar power production can be integrated into the facades of buildings or even into windows. Wave power will probably not be available for commercial applications until the 2020s at the earliest. New crops may be utilised in the production of arable energy.

Renewable energy has many benefits. If used sustainably, it can be used indefinitely, unlike fossil fuels or uranium, which will run out sooner or later. Almost all renewable energy used in Finland is produced domestically, and thereby its benefits to the local economy are distributed all over the country. Fuel-less renewable energy sources – wind power, heat pumps, solar energy – are emission-free in use and have low running costs. Renewable energy sources also employ more people per energy unit than average.

Renewable energy sources also involve challenges. Biomass resources are finite, and their overuse may cause damage to the natural environment. Small-scale wood burning using traditional technology generates large amounts of particulate emissions that are hazardous to health. Wind power and solar energy production varies with the weather, which places requirements on the energy system. Many forms of renewable energy, such as wind power, are also capital-intensive.

The scenarios in the foresight report indicate that even if all other means, such as improving energy efficiency, adding nuclear power or employing carbon capture and storage were used to their full extent, the use of renewable energy must nevertheless be substantially increased in order to achieve a zero-emission energy system. It is even feasible that by 2050, Finland will have an energy supply completely based on renewable energy sources.

Increasing the use of renewable energy requires that financial incentives are put in place to make it more attractive than emission-producing forms of energy. This could be implemented through various policies and measures improving the profitability of renewable energy (e.g. feed-in tariffs, demonstration support) and raising the cost of emissions (e.g. emissions trading, taxation). Administrative obstacles to renewable energy production – permits, impact assessment and land use planning – also need to be reduced.

Increasing the use of bioenergy substantially requires great changes in the ways in which biomass is obtained and used. So far, bioenergy has largely been produced as a by-product of the forest industry, but in the future an increasing amount of biofuel will probably have to be harvested separately for energy production. The harvesting and logistics chain must be improved to secure transports. Thousands of new, trained employees will be needed in the bioenergy sector.

Coal without carbon emissions

Carbon capture and storage (CCS) enables the use of fossil fuels and peat in energy production so that the process is virtually emission-free. This technology is particularly needed in places like China, which has abundant coal resources.

There are three potential technologies: post-combustion, pre-combustion and oxyfuel combustion. The captured carbon dioxide is stored in liquefied form, for instance in deep saline aquifers or in depleted oil and gas fields. In the future, it may be possible either to store crystallised carbon dioxide at ground level or to recycle it.

The technology for the components of CCS already exists, and the first test facilities are already running. However, CCS has not yet been applied commercially on a large scale. According to the IEA, halving emissions worldwide would require this technology to be widely available in the 2020s, which means that there is not much time to progress from demonstration to commercial use.

There are several factors limiting the introduction of the technology, such as:

- cost: at present the technology is expensive, for instance because it substantially increases fuel consumption
- efficiency: currently the technology can only capture part (80 to 90 per cent) of the carbon dioxide produced
- time: retrofitting old power plants with CCS is more expensive than installing it in new power plants, which will make introduction of the technology slower
- storage: there is a limited number of sites suitable for safe storage, and these are not necessarily located in the proximity of emission sources

Whether CCS becomes widespread depends above all on its costs. In test projects, the cost of emission reduction has been calculated as EUR 60 to 90 per tonne of carbon dioxide. With widespread use, this could fall to EUR 30 to 45 per tonne by 2030. By then, CCS would probably be an economically competitive way of reducing emissions with prices of emission rights at that time.

In Finland, there is a plan to test CCS at the Meri-Pori coal-fired power plant. The lack of suitable storage locations in Finland is a hindrance to the use of this technology. The only practical options are to pump the carbon dioxide along pipelines or transport it in tankers to a suitable storage location, for instance in the Norwegian Sea, and this will add to the cost of the system.

If the obstacles to CCS can be removed, it may have a role to play in a low-carbon Finland. CCS may help reduce emissions in metal industry processes and in energy production in major cities along the coast (e.g. Helsinki and Oulu) – applications where emission reductions are otherwise very challenging to achieve. VTT Technical Research Centre of Finland estimates that by 2050 CCS could cut annual carbon dioxide emissions in Finland by 7 to 13 million tonnes.

The most interesting possibility from the viewpoint of long-term radical low-emission paths is combining carbon capture and storage with bioenergy production. Because biomass sequesters carbon dioxide as it grows and CCS stores carbon dioxide, bio-CCS would be a system that produces energy with negative emissions. Thanks to Finland’s abundant biomass resources, the country is well placed to employ bio-CCS in order to achieve carbon neutrality. Finland also has an obligation to develop this technology, as by many estimates it may be of vital importance in reducing global emissions to a sustainable level.

In moving towards a zero-emission energy system, the use of fossil fuels and peat in its current form must gradually be abandoned. Thus, all new fossil-fuel and peat power plants must be required to be CCS ready. Alternatively, a gradual tightening of emission performance standards could be introduced to steer new power plants towards applying the technology.

Emissions can also be reduced by replacing emission-intensive fuels with natural gas. By 2020, the annual emissions of energy production in Finland could be reduced by 8 million tonnes by using natural gas. This would require expansion of the pipeline network and the construction of efficient combined-cycle power plants. The greatest challenge would be securing the energy supply, since this scenario would increase dependence on Russian imports. Focusing peat extraction on peatlands that have already been drained would also reduce emissions.

In energy production, it makes sense to use waste that is easy to burn but difficult to recycle. This includes waste wood, non-recyclable paper and cardboard, some fibre packagings and most household plastic waste. It is often best for the climate to digest biodegradable waste into biogas, which can then be used for energy production. In the future, fibre waste can also be used to produce bioethanol for transport fuels.

The role of nuclear power

Nuclear power generates no direct greenhouse gas emissions, and according to most estimates, its life-cycle emissions are also very low. Nuclear power plants are well suited to producing base load power, i.e. large amounts of electricity at a steady rate. Nuclear power has also been quite inexpensive in Finland so far.

Interest in nuclear power has increased worldwide in recent years. Estimates of future developments vary considerably. By 2030, the world's current nuclear power production capacity of 370,000 MW is estimated to have developed into 285,000 to 730,000 MW. Most of the potential additional capacity is expected to be built in Asia, whereas in Europe nuclear power capacity is expected to decrease.

Worldwide, nuclear power may have a role to play in emission reductions. According to the IEA, nuclear power could account for 6 per cent of the emission reductions needed in the energy sector by 2050. The IPCC, on the other hand, estimates that by 2030, nuclear power could account for 18 per cent of the world's electricity production, compared with 16 per cent today.

The IPCC further notes that the added use of nuclear power is limited by safety problems, the proliferation of nuclear weapons, and nuclear waste. In many countries, it has proved difficult to make the construction of new nuclear power plants a profitable business on the open market. Also, in many countries negative public opinion has made it difficult to build more nuclear power capacity.

There are four nuclear reactors in operation in Finland, and a fifth one is being built at Olkiluoto. The current power plant units will probably be decommissioned in the 2030s or in the 2040s at the latest. Whether their output will need to be replaced will depend on electricity consumption at that time and on the availability of electricity produced by other means. Replacing the existing power plants or building completely new power plants will eventually be decided in accordance with the Nuclear Energy Act.

The potential of nuclear power for reducing emissions depends on what the electricity that it produces is used for. Insofar as nuclear power replaces condensing power produced using fossil fuels or peat, it reduces emissions substantially. However, insofar as additional nuclear power covers an increase in consumption and replaces imports, it does not reduce emissions in Finland. A calculation where new production is assumed to replace the electricity that is on offer on average on the Nordic electricity market shows that a sixth nuclear reactor would reduce emissions in Finland by about 2 per cent.

The climate benefits of nuclear power improve if the heat generated as a by-product can also be used. In such a case, nuclear power could, to some extent, replace fossil fuels in the district heating production of cities. On the other hand, using the residual heat in this way would reduce the amount of electricity produced by the nuclear power plant and other plants through combined heat and power production. In the future, nuclear power could possibly also be used for extracting hydrogen from water.

The aim of new nuclear power technologies is to improve the efficiency of power plants and the efficiency of uranium use, reduce investment costs, reduce the amount of nuclear waste generated, and improve safety. These fourth-generation technologies are being studied by the Generation IV International Forum (GIF), of which Finland is a member.

The GIF project estimates that fourth-generation power plants could be taken into commercial use around 2030 to 2045 at the earliest, depending on the type of power plant. In Finland it has been estimated that at most 2,000 MW of capacity could be based on new technologies by 2050.

Box 6.2 Fusion power

In fusion power, energy is produced not by splitting atom nuclei as in conventional nuclear energy but by fusing them. In theory, fusion power could produce a substantial percentage of the whole world's energy with virtually zero emissions. Fusion reactors are regarded as inherently safe, and they do not produce high-level waste with a long half-life.

The introduction of fusion is limited by the rudimentary development stage of the technology and high capital costs. It is thought that if test projects prove to be successful, fusion power may be commercially available in the 2050s. However, it is generally considered unlikely for fusion power to provide more than one third of the world's electricity supply by the end of this century or to bring about a reduction in emissions similar to that achieved through the use of renewable energy sources.

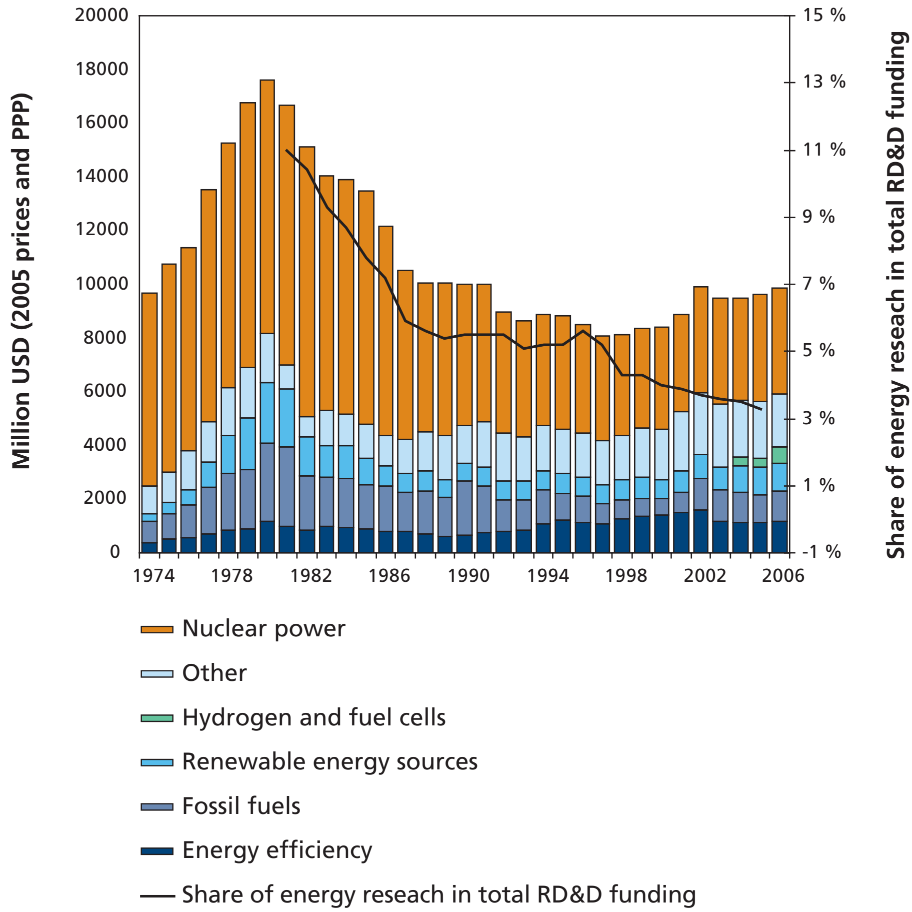
Sustainable technology is the key

According to several estimates, the technology needed for emission reductions of the next few decades is already principally on the market or just emerging. However, extremely low-emission paths will, in the long term, require improvements in existing technology and also completely new technologies that perhaps cannot even be imagined yet.

Technological development may lower the costs of emission reductions in the long term. The OECD considers that if significant technological breakthroughs were achieved in emission reductions worldwide, the cost per tonne of emissions could be halved by the middle of the century as compared with emission reductions using current technology.

The IEA has identified 17 areas that are important for emission reductions in the energy sector. Key technologies in energy production include carbon capture and storage, solar energy and second-generation biofuels. In energy use, by comparison, important areas include energy-efficient construction, hybrid cars and electric cars, and industrial motors.

Figure 6.4 Public R&D funding in the energy sector in the IEA countries



* Purchasing Power Parity

Source: Energy Technology Perspectives 2008. Scenarios & Strategies to 2050. International Energy Agency 2008, p. 172.

Publicly funded R&D on sustainable technology is principally undertaken in Finland by universities of technology and by VTT Technical Research Centre. The Finnish Funding Agency for Technology and Innovation (Tekes) provides funding for technology projects jointly run by businesses and the public sector. Sitra, Finnfund, Finnvera and Finpro all have a role to play in the deployment, diffusion and internationalisation of sustainable solutions.

In the near future, much hope rests on the Strategic Centres for Science, Technology and Innovation (SHOKs) in Finland. SHOKs involve key Finnish companies, research institutes and universities. The purpose of these clusters is to achieve technology leaps and to strengthen competitiveness, for instance in the forest and energy industries.

R&D aims at finding technically feasible and functional solutions. However, no solutions are implemented without there being a market demand for them. The OECD has estimated that simply multiplying R&D funding would not in itself substantially reduce emissions before 2040. In this scenario, the majority of the resulting climate benefits would not be actualised until the second half of the century.

Exploitation of technology thus needs to be both pushed by the research community and pulled by the markets. Measures creating and promoting demand include the emissions trading system, feed-in tariffs for renewable energy, and policies and measures guiding public procurement.

In international estimates, Finland is considered one of the world's leading countries in energy technology expertise relative to its size. The R&D focus has for a long time been on the research and development of new technology, but its deployment and diffusion has not been as successful. The trend is changing, and this needs to be accelerated.

Radical innovations and conscious risk-taking are needed for technological development. Low-emission paths require not only technological improvements but also social and business innovations. Policies must also guide towards user-oriented innovations, which will best serve the needs of various actors in their search for emission-reducing solutions.

Being a technologically and economically advanced country, Finland has excellent opportunities to develop sustainable technology for the world markets. International cooperation is needed in addition to domestic action. The European Commission has proposed that the world's R&D funding for energy technology should be doubled by 2012 and quadrupled by 2020. Finland must actively promote international cooperation for the development and commercialisation of sustainable technology.

A new cornerstone of the economy

Sustainable technology, or cleantech, can be considered to include all products and services that are less harmful to the environment than their alternatives. Examples of these are clean industrial processes, renewable energy, recycling and energy efficiency. Solutions in water supply, air protection and contaminated soil rehabilitation can also be included. One of Finland's greatest opportunities is a bio-economy based on the use of renewable natural resources.

The world market for sustainable technology has been growing steadily. Depending on the definition used, the market can be said to have grown by 10 to 30 per cent per year, until the financial crisis. Growth has been fastest in emerging economies: The market for renewable energy in China, India and Brazil grew by a factor of 14, to USD 26 billion, between 2004 and 2007. Morgan Stanley estimates that the market for clean technology worldwide can increase to one trillion (one thousand billion) US dollars by 2030.

Table 6.2 Development of renewable energy sources 2006–2008

	2006	2007	2008	
Investments in renewable energy production*	63	104	120	USD bn
Renewable energy production capacity**	207	240	280	GW
Wind power capacity	74	94	121	GW
Solar energy capacity (connected to the grid)	5.1	7.5	13	GW
Solar energy capacity (off grid)	2.5	3.7	6.9	GW
Solar heating*	105	126	145	GWth
Ethanol production*	39	50	67	bn litres
Biodiesel production*	6	9	12	bn litres

* annual

** excluding large-scale hydropower

The IEA has estimated that halving emissions from energy production worldwide would require an annual investment of one trillion dollars. This sum would cover investments in sustainable technology R&D, the additional costs of low-emission technologies, and private investments in the energy sector. On the other hand, the savings on fuel costs due to improving energy efficiency would cover a major share of the investment costs.

Investments in sustainable solutions create new jobs in the climate, energy and environmental sectors. Such 'green-collar jobs' may emerge, for instance, in

- renewable energy production and technology development
- energy renovations of buildings
- industrial reform and energy efficiency services
- repairs, reuse and recycling
- public transport and intelligent transport solutions
- repairs and construction of rail lines and bicycle and pedestrian traffic lanes
- organic farming, sustainable forestry and the bio-economy

The United Nations Environmental Program (UNEP) estimates that the wind power industry could create 2.5 million new jobs worldwide by 2020. Ten years later, solar cell production could offer another 6 million jobs or more, and biofuel production another 11 million jobs. In the EU, almost 3 million people could make a living improving the energy efficiency of buildings by 2030.

Prospects for exporting sustainable technology and services from Finland are promising. The wind power industry alone could involve 18,000 person-years by 2020, according to estimates made in the industry itself. Indeed, sustainable technology and services could become a new cornerstone of the Finnish national economy.

But success does not happen by itself. This was demonstrated by the fact that in the early 2000s export growth was slow and the market share of Finnish companies shrank. An encouraging framework must be built for exports.

The domestic market plays a crucial role, since here companies can demonstrate their solutions and gather the references required on the export market. The more Finland encourages the use of sustainable technology and services, by means of various policies and measures, the better chances Finnish companies will have to cope in tough international competition. Being a leader in climate protection supports success in the growing market.

The Government's policies

- Technological leaps in the metal and forest industries are supported through research, development and demonstration.
- Efforts are made to achieve climate targets without jeopardising the competitiveness of the economy by minimising the threat of carbon leakage.
- In order to reduce adverse effects to competitiveness, the aim in climate negotiations should be to achieve an agreement that is as comprehensive and binding as possible. National emission targets can be augmented with sector-specific obligations in developing countries.
- ICT is used in all sectors to help reduce emissions. The potential of ICT and the measures required are explored.
- A road map will be drawn up of ways in which farms can, in the next few decades, first become energy self-sufficient and eventually producers of energy.
- The target is set to achieve a virtually emission-free energy system in the long term. This requires the gradual phasing out of fossil fuels and peat as power plants are decommissioned, unless carbon-capture technology is installed.
- Energy conservation and improving energy efficiency are given priority in emission reduction. Potential for boosting energy efficiency investments by businesses by allowing quick depreciation is explored.
- Research into and preparation for a pan-European supergrid are promoted. Decentralised production of energy by consumers is promoted through administrative and financial means.

- The share of renewable energy in energy production is increased substantially. Possibilities of integrating large amounts of wind power capacity into the national grid are explored and the costs are estimated.
- Carbon capture and storage (CCS) technologies are developed and tested. In particular, the possibility of generating bioenergy with negative emissions through CCS will be explored.
- Various options are studied, and preparations are made to replace the nuclear power plants to be decommissioned from the 2020s onwards with emission-free solutions in both production and consumption. These may include, for example, wind power and nuclear power.
- Financing for development of climate-friendly and sustainable technology and services is increased, with particular emphasis on the deployment and diffusion of technologies.
- Climate and energy policy are utilised to support the creation of a domestic markets for sustainable technology. Efforts will be made so that sustainable technology becomes the new cornerstone of the Finnish economy.

7 CLIMATE PROTECTION AND EVERYDAY LIFE

People want to participate in climate protection, but they need support and guidance to do so. Sustainable transport options must be encouraged through urban and regional planning and transport policy. The use of fossil fuels in cars must gradually be phased out. In the future, new buildings must be as self-sufficient in energy as possible, and the energy efficiency of old buildings must be significantly improved. Consumers must also have sufficient information for making sustainable food choices.

The transition to a low-carbon society requires significant changes in the ways we use and produce energy, move around, consume, work and spend our free time. The climate load can be clearly reduced through choices made by public administration and businesses. However, following a very low-emission path also requires that citizens make an extensive and permanent contribution to the climate effort.

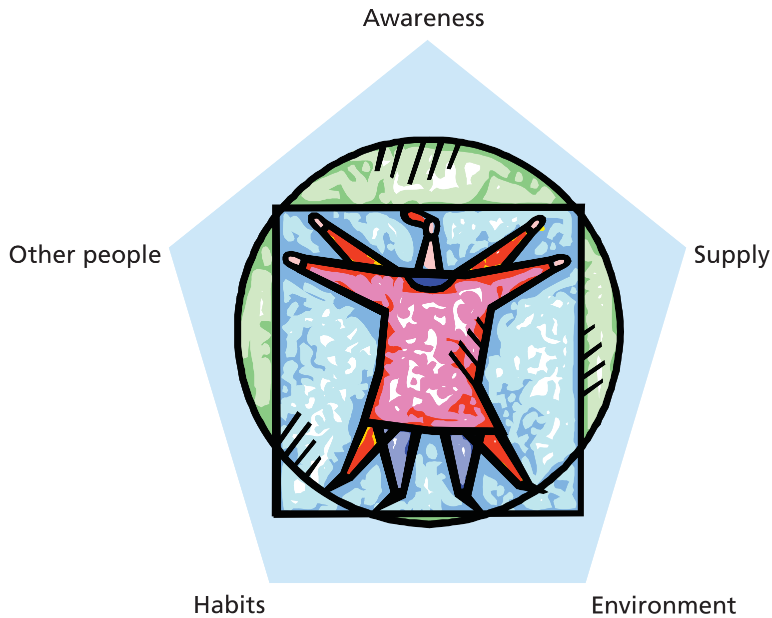
Values and attitudes are vital for climate protection. The readier people are to take action to reduce emissions, the better climate policy instruments will work. On the other hand, the more concerned citizens are about climate change, the more willing they will probably be not only to accept but also to demand a robust climate policy.

Opinion polls show that a clear majority of Finns are concerned about climate change and are willing to take action to reduce emissions. This concern and the willingness to act are high in all population groups, although there are some differences according to gender, age, geographical location and socioeconomic status.

On the other hand, studies indicate that, despite a general willingness to change, people actually take action less frequently than might be expected. There are several obstacles to turning words into deeds:

- lack of information: What is actually the best solution for the climate?
- everyday distractions: Should I protect the climate, or choose the easiest and cheapest option in any given situation?
- free riding: Why should I reduce emissions if my neighbour goes on living as before?

Figure 7.1 Factors affecting consumer behaviour



Besides awareness, many other factors affect people's everyday choices. These include customary behaviour, the environment, the supply of products and services, and the behaviour of other people. All five factors must be influenced when guiding people towards climate-friendly choices.

Source: Heiskanen, E. 2009. National Consumer Research Centre.

Individual decisions largely depend on decisions made by society. Decision-making must firmly point the way towards a low-carbon society, and policies must systematically endorse this objective. Society must make it easy and encouraging for individuals to make climate-friendly choices. This requires information, norms and financial policies.

Citizens must be given concrete tools to facilitate participation in climate protection. One such tool could be the decentralised small-scale production of renewable energy. The work of NGOs and citizens' groups in disseminating climate-friendly solutions must also be supported.

Major emission sources in everyday life

Most of the climate load generated by Finns in their everyday lives comes from three sources: transport, housing and food. Measures should primarily be focused on areas with the greatest potential for reducing emissions.

Transport accounts for just under one fifth of Finland's total emissions. Between 1997 and 2007 transport emissions increased by more than 15 per cent. More than half of transport emissions is caused by passenger cars.

The transition to a low-emission transport system requires above all improvements in vehicle technology and energy efficiency. Transport demand must also be reduced, the attractiveness of public transport as well as pedestrian and bicycle traffic increased, and fossil fuels gradually phased out.

Residential and service buildings use about 40 per cent of the energy consumed in Finland and generate nearly 30 per cent of its total climate emissions. Increased efficiency in the use of heating energy and household electricity and the adoption of low- and zero-emission energy sources can significantly reduce the burden caused by housing.

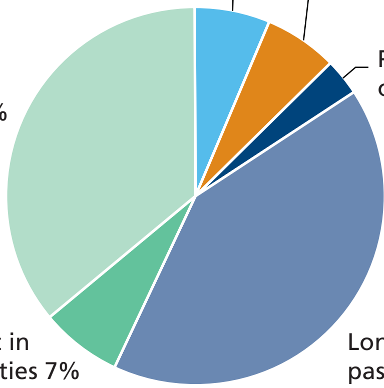
Food accounts for nearly one fourth of the climate load caused by the Finns' private consumption in their everyday lives. Most of this comes from products of animal origin. Emissions caused by food can be substantially reduced through many different choices and diets.

Public policy decisions must promote the spread of climate-friendly ways of life. The best-case scenario is that low-emission everyday life will become generally attractive. In addition to policies, peer pressure through social networks, communities and groups is also needed.

Low-emission transport system

There is roughly one car per two persons in Finland – above average for the European member states of the OECD. The average age of cars is 11 years, and the average age at which they are scrapped is 18. More than half of the kilometrage recorded in Finland comes from visits and leisure travel. Commuting accounts for just over a quarter, and shopping and business trips for about one third.

Figure 7.2 Distribution of carbon dioxide emissions from transport by type



About 64% of carbon dioxide emissions originate in passenger traffic and about 36% in the transport of goods. Nearly two thirds of carbon dioxide emissions from passenger traffic stem from traffic over long distances between sub-regions. This also includes emissions from ships and airplanes.

Source: Kalenoja, H., Mäntynen, J., Kallberg, H., Jokipii, T., Korpela, K. & Kulmala, M. 2002. Liikenteen hiilidioksidipäästöjen vähentämismahdollisuudet Suomessa. [Potential for reducing carbon dioxide emissions from transport in Finland] CLIMTECH research programme, Mobile 2 research module. Tampere University of Technology, Traffic and transport studies 48. Tampere. p. 11.

Emissions from cars can be reduced in four principal ways:

- by improving energy efficiency through vehicle technology and by adopting low-emission energy sources
- by reducing the transport demand
- by steering citizens towards public transport and bicycle and pedestrian traffic
- by introducing financial policy measures

Measures in all four categories are required for the attainment of a low-emission transport system. Transport demand can be reduced by improving cohesion of the urban structure, safeguarding local services and promoting telework and e-transactions. If daily services are comprehensively available within walking distance, there is less need to use a car. Reducing the transport demand does not mean imposing restrictions on transport; instead, it refers to enabling an everyday life in which people do not have to move around as much as they do now.

In the transport policy of the future, new solutions must be sought instead of the traditional investment-intensive policy. The 'four-step principle' offers means for doing this. According to this principle, the first response in addressing transport issues should be checking whether the issue could be resolved by influencing demand. After this, potential for enhancing the existing transport system is explored. New traffic route projects are not even considered until and unless it becomes apparent that minor improvements to existing routes will not solve the issue.

Many European countries have had good experiences of mobility management. The point is to consider the transport system as a comprehensive entity and to promote sustainable mobility through awareness-raising, coordination and easier combination of different means of transport. In some workplaces, car commuting has been cut by 10 to 30 per cent. The system can be organised in national service centres and regionally for the largest urban areas.

There is also promise in 'intelligent transport', which means the application of ICT to transport systems. Intelligent transport applications include traffic signal priority for public transport, displays showing waiting times, and WiFi networks for passengers. Applications for car drivers include congestion and disruption notifications, driver guides, automatic collision alerts and GPS-based road user charges.

Intelligent transport solutions are often highly cost-efficient. Many estimates indicate that they could represent a major break-through in transport with regard to climate protection in the nearest few decades. An increase in videoconferencing alone could reduce work-related domestic trips taken by air and by car by 10 to 15 per cent.

Great expectations in vehicle technology

There are several ways in which energy efficiency in car transport can be improved. Current internal combustion engines can be technically enhanced, cars can be made lighter, and petrol can be replaced with diesel. Hybrid cars with both an electric motor and an internal combustion engine can cut fuel consumption by some 30 per cent, rechargeable hybrid cars by even more.

Fossil fuel petrol and diesel can be replaced, especially in passenger cars, with natural gas, biofuels and electricity. Biofuels vary hugely in their climate balance: the best biofuels reduce emissions to a fraction of their current level, while some alternatives may even generate more emissions over their lifecycle than petroleum-based fuels. Biofuels whose raw material production requires the destruction of pristine forests are particularly harmful.

The biofuels most favourable to climate are those produced from waste, such as biogas produced through the digestion of sludge from farms and waste water treatment plants, as well as ethanol produced from waste generated by the food industry and fibre packagings. A good climate balance has also been achieved in second-generation biofuels produced from wood or straw cellulose or algae. In the future, biofuel raw materials such as the jatropha bush will probably be cultivated in the tropics on marginal lands unsuitable for food production.

One of the most promising ways of reducing emissions in the medium and long term is the introduction of electric cars. An electric motor is substantially more energy efficient than an internal combustion engine, and thus replacing the current car stock with electric cars would reduce emissions even if the electricity used to power them were mainly produced using fossil fuels. It has been estimated in the USA that the majority of the country's current car stock could be replaced with rechargeable hybrid cars by using existing electricity production capacity outside peak hours, with no need to build new capacity.

A reduction of about 30 per cent in car traffic emissions could be achieved simply by increasing the percentage of rechargeable hybrid cars in Finland to 50 per cent, assuming that these cars would principally use the electricity currently available on the Nordic market. Future technology will enable completely zero-emission car traffic: electric cars running on electricity produced without emissions. However, all forms of electricity production have their own adverse effects, so even electric car traffic would not be wholly without problems.

The rapid introduction of electric cars requires government action. Financial policies and measures can be used to make the acquisition of electric cars more attractive. R&D funding can help technological advances, and public-private partnerships in cities can help build the required recharging and battery replacement networks. By launching pilot projects rapidly, Finland could take the lead and use the experiences gained to drive exports. By 2050, the car stock will have been replaced several times over, so the potential for switching to emission-free vehicles exists.

In the long term, hydrogen could also be a viable alternative. VTT Technical Research Centre of Finland estimates that cars with fuel cells powered by hydrogen could become common beginning in the 2020s. However, the widespread use of hydrogen as a fuel will require significant technological advances and substantial investment in its production, distribution and use. How climate-friendly hydrogen is depends on how it is produced. Car manufacturers are currently also investigating the use of compressed air as a source of transport power.

The target set by the European Union is to reduce the average emissions of new cars sold to 130 grams of carbon dioxide per kilometre by the year 2015. By 2020, emissions must be reduced to 95 g CO_2/km.

In the long term, emissions must continue to decrease considerably so that road traffic will gradually become nearly emission-free. The most important factors in reducing the specific emissions of cars are engine technology, electric cars and biofuels.

Finland sets a guideline target, according to which the direct specific emissions of cars will be at most 80–90 g CO_2/km in 2030. Emissions must also continue decreasing thereafter so that they are at most 50–60 g in 2040 and 20–30 g in 2050. These figures comprise the use of fossil fuels in transport, whereas emissions from the electricity and biofuels used in cars are included in their production balances. Determined effort must also be made to cut emissions from the production of electricity and biofuels.

Reaching the emission targets of cars depends on the global development of vehicle technology. The adoption of energy-efficient cars and low-emission energy sources can be accelerated with the help of strong domestic steering measures, such as taxes imposed on driving. On the basis of the scenario work carried out for the report, it seems that emissions from cars may need to be reduced even more than indicated above. In addition to measures targeted at the specific emissions of cars, it is necessary to take effective measures to influence the transport demand and modal split.

Box 7.1 Reducing air transport emissions

Air transport actually accounts for a relatively low percentage of the world's total direct climate emissions, about 3 per cent. However, the load generated by aircraft through nitrogen oxides and concentration trails is up to two to four times greater than that of carbon dioxide emissions. Also, aircraft may accelerate the formation of clouds that contribute to global warming.

The rapid growth of air traffic is also a problem. For example, between 1990 and 2005 air traffic emissions in the EU increased by 85 per cent while the combined emissions of the EU otherwise remained almost stable.

Emissions from air traffic can be reduced for instance by increasing the capacity rate and by developing routing, air traffic control and technology. Continuous descent approach (CDA) can cut emissions in landing by 10 to 30 per cent. Jet airliners with energy efficiency ratings 20 per cent better than at present are expected to come onto the market around 2015. However, the replacement rate in the worldwide aircraft fleet is low.

A major percentage of current domestic flights in Finland can be replaced by higher-speed rail services. The inclusion of international air traffic in the EU emissions trading system is an incentive to rationalise flying. Removing tax concessions for airlines would have a similar effect.

In the long run, alternative fuels might be one solution. The aviation industry is already testing engines that run on a mixture that is half biofuel. The International Air Transport Association (IATA) has set the target that 10 per cent of all fuel consumption should be covered with alternative fuels by 2017.

Promoting public transport and bicycle and pedestrian traffic

Public transport only accounts for 8 per cent of all trips taken and only 16 per cent of the total kilometrage at present. Almost half of all commuting by schoolchildren and students is done by public transport while the corresponding figure for shopping and business trips is only 6 per cent. Promoting the use of public transport as well as pedestrian and bicycle traffic will not only reduce transport emissions but also cut down on congestion, noise and accidents while improving mobility.

The popularity of public transport can be increased by making connections quicker, by increasing the supply, by reducing ticket prices and by improving the quality of the service. Ticket prices can be reduced by making operations more efficient and increasing competition, by cutting taxes (such as the public transport fuel tax and VAT) and by increasing public subsidies. Improving park-and-ride facilities will help car drivers switch to public transport. Increasing the attractiveness of the employer-subsidised commuter ticket would increase the use of public transport for commuting.

Promoting public transport also requires investment, particularly in rail tracks. It is vital for both passenger and cargo transport to build more tracks, including passing tracks, on crowded rail lines. Improving rail line capacity will cut down on delays and enable more frequent train services. Regional centres must be linked with each other and with the Helsinki area with far faster train services than at present. This will reduce some of the domestic air transport demand and encourage people to switch from road to rail. In major urban areas, there is considerable potential for commuter trains and light rail transport.

In the long run, completely new rail lines will be needed. Rail projects in future decades should be prepared for well in advance. Projects must be evaluated from the point of view of overall economy.

The potential for walking and cycling can be improved for instance by building a comprehensive, safe and enjoyable pedestrian and bicycle traffic network. There should be safe cycle parking facilities at service locations, at stations and near homes.

International experiences indicate that it is unlikely that emissions could be significantly reduced merely through incentives, without simultaneous restrictions on car driving in urban areas. The most effective way of influencing transport behaviour is a combination of stick and carrot: making sustainable solutions more attractive and unsustainable solutions less attractive. However, car traffic cannot be restricted in areas where a car is the only feasible transport option.

Box 7.2 Summer cottages and climate protection

About four fifths of the energy consumption related to leisure-time dwellings is caused by transport. Finns make over 5 million trips to and from summer cottages every year; 95 per cent of these trips are made by private cars. Summer cottage trips account for about one fifth of all leisure trips taken in Finland. However, it is possible that trips to and from summer cottages may replace other leisure travel.

The climate load from leisure-time dwellings has increased because there are more cottages than before, they are larger, and they are better equipped. One in five Finnish summer cottages is heated throughout the winter; of recently built cottages, more than 60 per cent. Summer cottages consume about 800 GWh of electricity per year. Two people staying at a summer cottage regularly produce roughly the same climate load as if they flew to Thailand for a holiday once a year, assuming that the cottage is kept at a standard temperature with electric heating and they drive to the cottage by car.

Visits to summer cottages should also be turned into a low-emission activity. Standard-level heating to keep the cottage dry cuts down on the overall heating need, and with a frost-resistant water supply system the building can be kept cold during winter.

Renting and shared use can reduce the amount of space that needs to be heated. Decentralised renewable energy production is also an option for summer cottages. Demand-responsive transport services and the location of cottages within reasonable reach of public transport can help reduce the number of car trips.

Aiming at an eco-efficient urban structure

Urban structure is relevant in terms of emissions in many ways. In urban and built areas, a dispersed structure increases the load per resident from building and maintaining the infrastructure, and district heating, for example, is difficult to provide. A dispersed structure also increases the cost of providing services and the time spent in transport.

Especially in the urban areas of large cities, but also in other urban areas, a dispersed structure translates into long distances between home, work and services, thereby adding to the transport demand – or, more accurately, compulsory mobility. With long distances, bicycle and pedestrian traffic is rarely an option, and there is not enough of a customer base for well-functioning public transport. For example, in small suburbs on the outskirts of the Helsinki metropolitan area, the car kilometrage per resident is four times larger than in the pedestrian areas of the large cities.

Changes in urban structure take place very slowly. Once built, the structure of a community guides and to some extent forces residents to make certain kinds of choices even decades later, and changing the structure later is extremely difficult. We must consciously build low-emission urban structures today, and we must seek sufficient policies and measures to ensure this.
Finnish studies show that differences in solutions for urban structures may have an impact of up to 10 per cent on greenhouse gas emissions at the regional level and as much as 50 per cent at the residential area level. In densely built urban areas, traffic emissions per square metre of dwelling space are the lowest; in sparsely populated areas, they are considerably higher. VTT Technical Research Centre of Finland estimates that by slowing down urban sprawl, the car kilometrage in 2050 could be reduced by 12 per cent compared with the trend likely to occur otherwise.

Sufficient population density and development corridors improve the potential for public transport. A minimum of 20 residents per hectare is enough to sustain a well-functioning public transport system. However, the percentage of Finland's population living in areas such as this has declined in the past 15 years in all large and medium-sized urban areas, except for Helsinki. The average length of a commute in Finland has also more than doubled over the past two decades.

Even a densely built residential area can be small in scale and cosy. For example, the Lehtovuori district of Konala in Helsinki consists of two-storey wooden houses yet has an area density similar to that of 1970s suburbs made up of blocks of flats.

A cohesive urban structure does not require all housing to be concentrated in large cities. An optimum community size with regard to internal traffic is on the order of a small or medium-sized town; in such a community, nearly all places can be reached by walking or cycling. Building small, relatively narrow but densely built communities along rail lines and other public transport corridors is a model in which dense urban structure and proximity of the natural environment coincide. In the Greater Helsinki Area, the urban areas now form a grid, so both transverse and longitudinal public transport connections are needed.

In urban areas, homes, services and jobs must all be easily accessible through the use of public transport and to bicycle and pedestrian traffic. This requires regional and transport planning. Especially, functions that generate heavy passenger traffic must be placed within the existing urban structure or otherwise along good public transport connections. In the Helsinki area, the key issue is to make the immediate vicinity of stations a comfortable and safe environment. It is also important to increase job self-sufficiency in areas that are now a source of commuting elsewhere.

Different solutions are needed in urban and regional planning, depending on the area and the situation. In sparsely populated areas, even a dispersed structure may be good as regards climate policy if it means, for example, that the use of renewable energy is sustainable and better than in urban housing. It is possible to guide the energy use of housing that already exists in rural areas or is being established there so that renewable bioenergy obtained locally will increasingly be used and teleworking opportunities will be encouraged.

In line with the national land use guidelines, rural housing, public transport and other functions will be developed so that they support rural communities, village networks and infrastructure.

Towards the zero-energy house

There are more than 1.4 million buildings in Finland, most of them residential. The building stock is relatively new, and its annual replacement rate is about 1.5 per cent. District heating is the principal form of heating, but oil or electric heating is also used, especially in one-family houses.

Improving the energy efficiency of buildings is one of the most important and most cost-effective ways of reducing emissions. On the other hand, there are some particular challenges in the building sector. Building stock is long-lived, and its replacement rate is very slow. The majority of the buildings constructed today will still be in use in 2050. The decisions made today will determine in part how carbon-intensive a path Finland will set out on for the decades to come.

Owing to the importance of the sector, a target is set to make the energy use of the entire building stock more efficient so that in 2030, the energy consumption of buildings will be at least 30 per cent less than at present. In 2040, energy consumption will be 45 per cent less and in 2050 60 per cent less than at present. The energy consumption of the building stock is reduced by energy-efficient new buildings, removal of the old stock, and renovations to improve energy efficiency.

The energy efficiency of new buildings can be influenced through building regulations issued by the Ministry of the Environment by decree. The Ministry has decided to tighten the energy consumption standards by 30 per cent as of 2010. The aim is to tighten the standards by a further 20 per cent in 2012. At the same time, regulation based on overall energy consumption will be introduced, and the impact that the heating method has on emissions will be taken into account.

The proposed reforms will gradually reduce energy consumption in new buildings to a substantially lower level. However, building technology can enable even more energy-efficient solutions. The UK has set as a target that from 2016 onwards all new buildings will be zero-energy houses. In France, by comparison, the expectation is that in 2020 all new buildings should be plus-energy houses, i.e. they should produce more energy than they consume.

Both the International Energy Agency (IEA) and the European Commission and Parliament have recommended the adoption of passive houses. In Finland too, the ultimate objective should be that new buildings need no external heating energy at all. Plus-energy houses that produce more energy than they consume must also be promoted actively.

At the same time, more attention must be paid to other consumption, such as real estate and household electricity, and the need for hot water. In construction, building use and building maintenance, automation solutions should be effectively used and developed to improve energy efficiency (e.g. device control and monitoring, and consumption measuring and billing). Alongside improving energy efficiency, the quality and health-aspects of building construction must also be improved.

The greatest challenge lies in the existing building stock. In the 2010s in particular, and in the 2020s too, a significant number of residential buildings will reach modernisation age. However, so far energy efficiency has not been considered in renovation projects to any great extent. Building codes are generally considered a rather inadequate means of guidance as regards the existing building stock. On the other hand, in practice it is impossible to expedite improvements in energy efficiency to any significant extent through public subsidies when 2.7 million homes are involved.

In Denmark, there is a requirement to improve energy efficiency in connection with renovations and other significant alterations (e.g. replacement of doors and windows or installation of a heat recovery system), and an EU reform to this effect is being prepared. Indeed, there is reason to augment building regulations in order to require improvement of energy efficiency in renovations of existing buildings. According to the Energy Efficiency Committee, the energy efficiency of the existing building stock could be improved by 30 to 50 per cent. Energy standards should also be extended to apply to new leisure-time dwellings.

Sufficient means must be ensured to support energy reviews and energy efficiency renovations, especially for low-income households. It must also be acknowledged that in some cases the most sustainable and cost-effective solution is simply to tear down an old, energy-inefficient building and construct a new one. Because patterns of use have a major impact on consumption, information and guidance for residents are also needed.

According to a comparison conducted by the Finnish Environment Institute, blocks of flats use on average 241 kWh in heating per square metre of dwelling. As per the same comparison, the average consumption in single-family and terraced houses is significantly lower, 190 kWh per square metre of dwelling. This difference is explained by the heating required for staircases, hallways and storage space, for example. Consumption can partly be reduced by flat-specific heating energy consumption meters and invoicing.

Completely new measures should also be considered. Such measures could include differentiating real estate tax and plot rent according to the energy source and energy efficiency of the building on the plot, or granting extra building rights in exchange for substantial improvements in energy efficiency or for the adoption of a climate-friendly energy source. Expanding the scope of application of energy certificates and awareness-raising campaigns would support this, too.

Apart from the consumption of heating energy, the method for producing heat also affects heating-related emissions. Especially in single-family houses, emissions can be reduced considerably by using local renewable energy sources, such as pellets, heat pumps and solar collectors.

Besides improving energy efficiency, low-emission heating methods must be promoted. The use of fossil fuels and direct electric heating in all but the most energy-efficient buildings must be gradually phased out. As energy-efficient construction becomes more common, building-specific solutions will increase alongside district heating. Sustainable heating methods can be promoted through a combination of awareness-raising, incentives, taxes and building regulations.

Box 7.3 Wood construction and the climate

Also materials represent a component in the climate load attributable to buildings. Wooden structures require less energy to fabricate than concrete ones, and when using wood the secondary flows can be used to produce energy.

In principle, wooden buildings can be said to bind carbon from the forests. The Finnish Forest Research Institute (Metla) estimates that Finland's existing wooden buildings store more carbon than its annual national carbon dioxide emissions. Wood construction can also have export potential.

A Nordic study compared two alternative construction projects that differed only in that one maximised the use of wood structures and the other the use of concrete structures. Over a 100-year period, the concrete alternative was reckoned to have generated 230 kg of carbon dioxide per square metre of floor area. The wood alternative, by contrast, would actually save 260 kg of carbon dioxide per square metre of floor area. Maximizing the use of wood in new buildings could cut Finland's annual emissions by about 2 per cent.

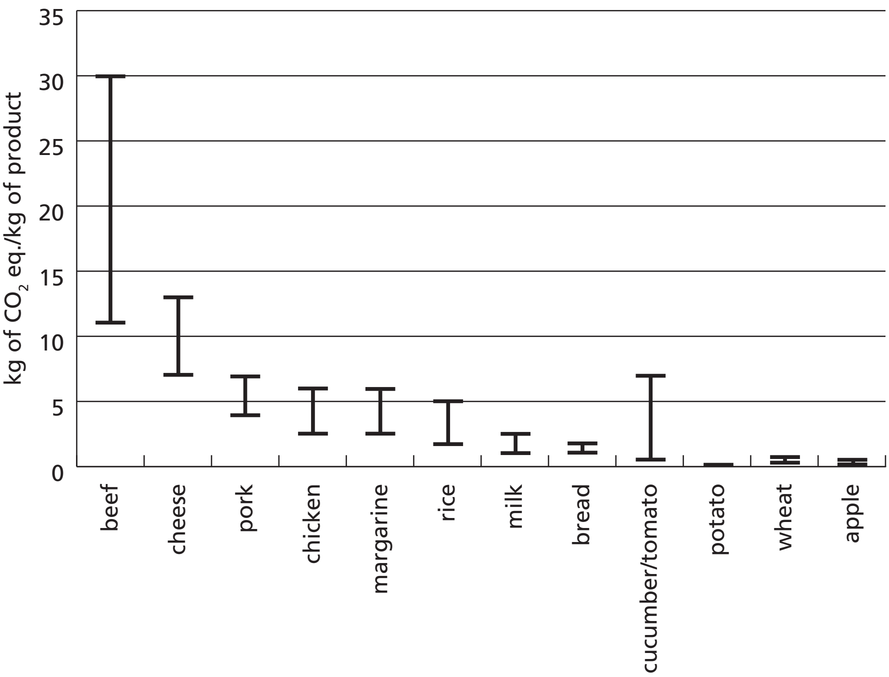
Climate-friendly food choices

Foods generate very different emission loads, and different products generate emissions at different stages in their life cycle. In the case of cheese, for example, about three fourths of its climate impact originates in agriculture. As for beer, the greatest load comes from distribution and trade, while the creamy potato and cheese casserole's largest climate impact is caused by its cold storage in the shop.

Consumer behaviour is also relevant. If oatmeal is prepared on an electric stove, the cooking is responsible for the majority of the overall emissions of the finished food. A microwave oven, by contrast, generates only a fraction of the emissions from cooking on an electric stove.

Packaging and transport generally account for rather a small percentage of the climate load. Indeed, in some cases it may be more advantageous for the climate balance to produce some foods in locations where the natural conditions are more favourable. For example, Finnish greenhouse vegetables produced using energy generated with fossil fuels usually create more of a climate load than vegetables imported from warm countries. This difference will, however, grow smaller as production in Finland becomes more efficient with global warming and the use of renewable energy increases.

Figure 7.3 Examples of the carbon balance of foods



Ranges of variation for the carbon balance of some foods estimated on the basis of various studies.

Source: Katajajuuri, Juha-Matti. 2009.

Generally, products of animal origin generate the largest climate load. According to a report by the UN Food and Agriculture Organization (FAO), livestock husbandry is responsible for one fifth of all emissions worldwide – more than transport. Half of this load comes from the deforestation caused by livestock husbandry and the other half principally from the methane emissions arising from the digestive systems of farm animals and from the nitrous oxide emissions arising from manure. The climate load of 1 kg of cheese is equivalent to a 60-kilometre drive by car.

However, there are differences among products of animal origin. The highest load is generated by beef and the lowest by game, assuming that acquiring game does not require extensive driving by car. If the average Finn were to replace the 18 kg of beef that he/she eats each year with chicken or pork, this would reduce his/her climate load by the equivalent of a flight to a holiday destination in southern Europe. A diet consisting mostly or wholly of vegetarian food is also a climate-friendly choice.

There are partly contradictory estimates regarding the climate loads of organic foods. No artificial nitrogen fertilisers are used in organic farming, which reduces agricultural nitrous oxide emissions. Energy consumption is also reduced: in

Swedish agriculture, for example, fertiliser production accounts on average for about 15 per cent of the total energy consumption.

On the other hand, the yield in organic agriculture is lower, meaning that more field area, more animals and more operating of machinery are needed to produce the same amount of food. This, in turn, increases the level of emissions. However, for various other environmental reasons it is principally recommendable to favour organic products.

Consumers can be advised towards making sustainable choices by providing reliable and accessible information on the climate impact of various foods. The nutrition 'plate model' could be joined by a climate-friendly 'plate model'. In the future, financial policies and measures could also be used to encourage consumers to make climate-friendly choices.

Mass catering has a substantial impact on food choices. Some EUR 300 million is spent on public-sector mass catering in Finland every year, with nearly 750 million portions served. Climate-friendly choices should be favoured in mass catering, too. The simplest and cheapest way to reduce the environmental load of food is to minimise wastage.

Box 7.4 Reducing emissions in the waste management sector

The waste management sector generates 3 per cent of all greenhouse gas emissions; this percentage has decreased substantially since the widespread introduction of methane recovery at landfill sites. However, there are still substantial and in many cases cost-effective ways of achieving further emission reductions in waste management.

The most sustainable way is, according to the waste hierarchy, to reduce the amount of waste produced and to improve material efficiency. Reuse and recycling can still be significantly increased.

It is also justifiable to use waste for energy production. Biowaste can be used to produce biogas or ethanol. Co-incineration of sorted waste at energy plants generates more electricity than mass incineration of mixed waste; this can be used to replace marginal electricity, which has a high climate load. The ultimate target is that the present-form landfilling of waste will no longer be necessary in the future.

Information to support choices

To support a low-emission way of life, people need accessible, independent and reliable information on the climate impacts of choices in their everyday lives. This information should be easily available on the one-stop shop principle at a single website, through a single email address and through a single phone number.

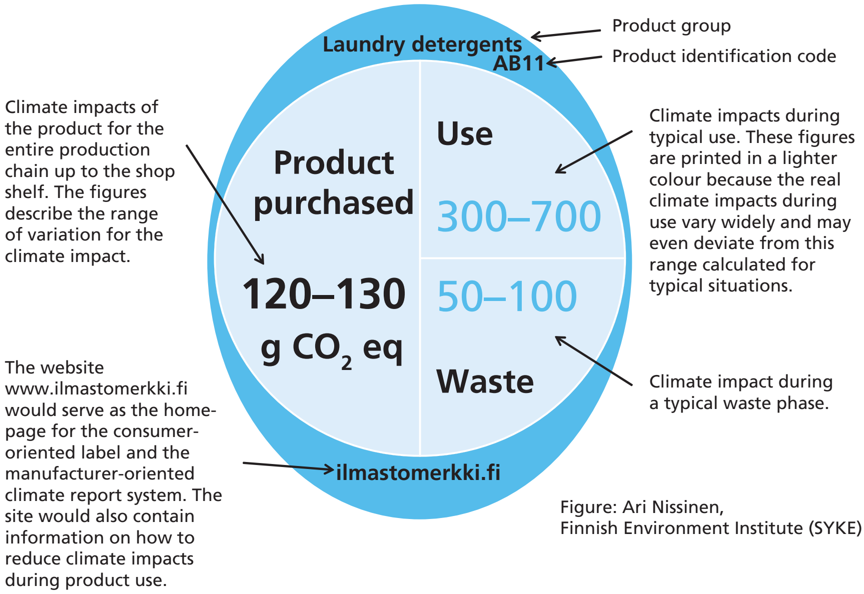
Some energy-consuming devices such as refrigeration equipment, washing machines and lamps now have an energy label. This seven-step coloured scale indicates how much energy the device consumes. It has guided consumer choices so that the most inefficient products have disappeared from the market and there is now a wider range of availability at the energy-efficient end of the scale.

Energy labelling has been extended from electrical equipment to some homes, and Finland is preparing to extend it to cars. This labelling should be extended to all devices and products that consume energy. The classification criteria should be updated regularly and the labelling developed to indicate clearly which products are the most energy-efficient.

Today, it is particularly difficult for consumers to compare the climate impact of various consumer goods. This information could be presented simply in the form of a climate label or emission specification sheet listing the emissions created through the production and use of the product. A climate label could support emission reductions in several ways:

- by requiring companies to determine the life-cycle climate impacts of their products
- by encouraging companies to develop low-emission products
- by drawing public attention to the climate impact of consumption and
- by guiding consumer selection towards low-emission products and product groups

Figure 7.4 An example of a possible climate label



Source: Nissinen, Ari & Seppälä, Jyri. 2008. Tuotteiden ilmastovaikutuksista kertovat merkit [Labels for indicating the climate impacts of products]. Background study to the Foresight Report of Prime Minister Matti Vanhanen's II Cabinet. Prime Minister's Office Publications 11/2008. p. 34.

Challenges are involved in establishing a comprehensive labelling system. For one, there is currently no generally accepted and reliable standard for calculating the climate impact of various products. Determining the carbon balance of a single product, even if the process is streamlined, may cost more than EUR 10,000, and consumer goods shops typically stock tens of thousands of different products. The costs may prove to be unreasonable, particularly for the smallest businesses. Moreover, several ecolabels are already in use.

The challenges should, however, be weighed against the need. The transition to a low-carbon society will in any case require radical change and completely new policies and measures. Finland should take an active approach to promoting international cooperation to develop calculation methods for climate labels and their standardisation and should also launch pilot projects. In addition, existing ecolabels can be used more effectively than at present.

Improvement of emissions calculations for products will make it possible to provide new kinds of consumer services in the future. Retail chains could offer emission monitoring to their customers through their loyalty card systems and could pay out bonuses for climate-friendly purchases. The monitoring could be linked to a help desk providing information on low-emission alternatives.

Box 7.5 Even small choices matter

It is often imagined that reducing emissions is laborious and expensive. However, in many cases all it requires is a bit of thinking and a change of habits. Several everyday actions one can take to reduce emissions also save money.

If Finland's Kyoto target were to be divided equally among the population of Finland, it would translate into a reduction in carbon dioxide emissions of 1,500 kg per resident per year. This can be achieved for instance as follows:

1. switch off the instant sauna stove: 640 kg
2. sort biodegradable household waste: 450 kg
3. switch off the PC when leaving work: 135 kg
4. replace one portion of beef with pork once a week: 120 kg
5. recycle one 1.5 litre plastic bottle per day: 120 kg
6. replace one portion of rice with potato once a week: 30 kg
7. donate a bagful of old clothes for reuse: 30 kg
8. recycle one aluminium can per day: 27 kg
9. wash clothes three times a week at 40 degrees instead of 60 degrees: 15 kg

It is true, though, that the reductions which will need to be achieved in everyday life by 2050 cannot be attained by just recycling cans and bottles. Significant changes must take place in society so that citizens can make sufficiently sustainable choices.

The Government's policies

- Allowance is made for investments required to attain long-term emission goals in public transport. Funding for transport routes is increased and allocated to sustainable transport projects.
- The establishment of national and regional mobility service centres is promoted. Intelligent traffic solutions are applied widely in order to reduce emissions.
- The adoption of low-emission vehicles is promoted through tax and standards incentives. Pilot projects to speed up the introduction of electric cars are launched.
- A target set is that specific emissions from cars will not exceed 80–90 g CO_2/km in 2030, 50–60 g in 2040 and 20–30 g in 2050. If vehicle technology develops fast enough, provision is made for even more rapid emission reductions.
- Sustainable biofuels, produced from waste or other raw materials that do not compete with food production, are favoured. Policies and measures are allocated according to the carbon balance of each fuel, and unsustainable options are abandoned.
- More research is conducted on how urban structures influence emissions. Information and planning tools illustrating climate impacts are produced to help in urban and regional planning.
- In urban areas, regional cooperation is promoted in urban and transport planning, and in the siting of services and jobs. The potential of policies and measures to alleviate the climate impact of urban structure is studied.

- Planning guidance is enhanced in urban areas in order to improve cohesion of the urban structure. The potential of local authorities to steer dispersed construction towards village and municipal centres is explored and supported.
- Comfortable and human-scale forms of housing consistent with a cohesive urban structure are developed and adopted. Wood construction is promoted.
- The target set is to improve the efficiency of energy use in the entire building stock so that in 2030, the energy consumption of buildings will be at least 30 per cent less than at present. In 2040, energy consumption will be 45 per cent less and in 2050 60 per cent less than at present.
- The energy standards for new buildings will be revised after 2012 to facilitate a gradual transition to passive houses. Zero and plus energy construction will be promoted through research and development, pilot projects and financial policies and measures.
- Substantial improvements in energy efficiency will be required in extensive renovation projects in existing buildings. Measures are taken to ensure that leisure-time dwellings become more energy-efficient.
- More research and information sharing will be undertaken concerning the climate impact of food. The potential for using financial policies and measures to favour climate-friendly food choices is explored.
- Efforts are made to cut food wastage in half, at the minimum.
- Recycling and energy use of waste, and prevention of waste production, are substantially increased. The present-form landfilling of waste will gradually be abandoned.
- Information concerning the climate impacts of everyday choices will be made easily available to citizens on the one-stop shop principle. Sufficient resources are ensured for awareness-raising.
- The extended application of energy labels in the EU is promoted; so, too, the development and piloting of climate labels on products. The least energy-efficient office equipment and household devices will be removed from the market through efficiency norms.

8 ADAPTATION TO CLIMATE CHANGE

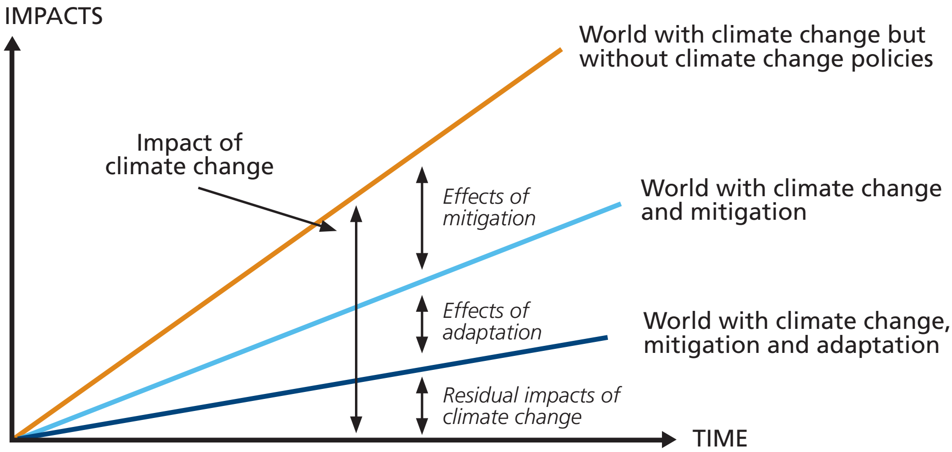
The direct impact of moderate climate change will probably not be excessively large in Finland. However, in a globally interdependent world, problems elsewhere are reflected here. The quicker global warming progresses, the greater the risks are. Finland has been a leader in preparing for climate change, but these efforts must be continued and strengthened. Low-income developing countries have the least capacity to adapt to climate change.

The adverse effects of climate change can be alleviated both by mitigating global warming and by adapting to its impact. The purpose of mitigating climate change is to avoid the adverse effects and risks that we do not want to or are not able to adapt to because of their severity. Adaptation, on the other hand, refers to measures designed for coping with existing or future impacts of climate change, such as the rising sea level, biodiversity loss or the increase of forced migration.

Mitigating climate change is the primary approach, because it prevents adverse effects from occurring in the first place. However, it is not enough, since many emissions have a long lifetime, and some degree of climate change is inevitable in any case. Even if the world's total emissions were cut to zero immediately, the global mean temperature would still continue to rise by about half a degree Celsius because of the greenhouse gases already in the atmosphere. Therefore both mitigation and adaptation are needed.

The lower the level at which global warming can be curtailed, the less adaptation will be needed. Similarly, the more aggressively the climate keeps warming, the more substantial, more difficult and more expensive the adaptation will be.

Figure 8.1 Climate protection helps mitigate global warming, and adaptation helps cope with its impacts



Source: European Commission. 2005. Winning the battle against global climate change. Commission Staff Working Paper. Background paper, p. 7.

The benefits of emission reductions will take decades to materialise. The effects of adaptation measures, on the other hand, will be felt immediately or in the near future. Reasonable adaptation measures may also support other social goals, such as protection against natural extreme weather phenomena.

Some factors contributing to the need for adaptation may emerge very quickly. In Arctic regions, melting of the permafrost has already weakened road conditions and the stability of the foundations of buildings. In the UK, there is debate over no longer repairing roads and houses succumbing to increasing coastal erosion, and not compensating their owners for such losses.

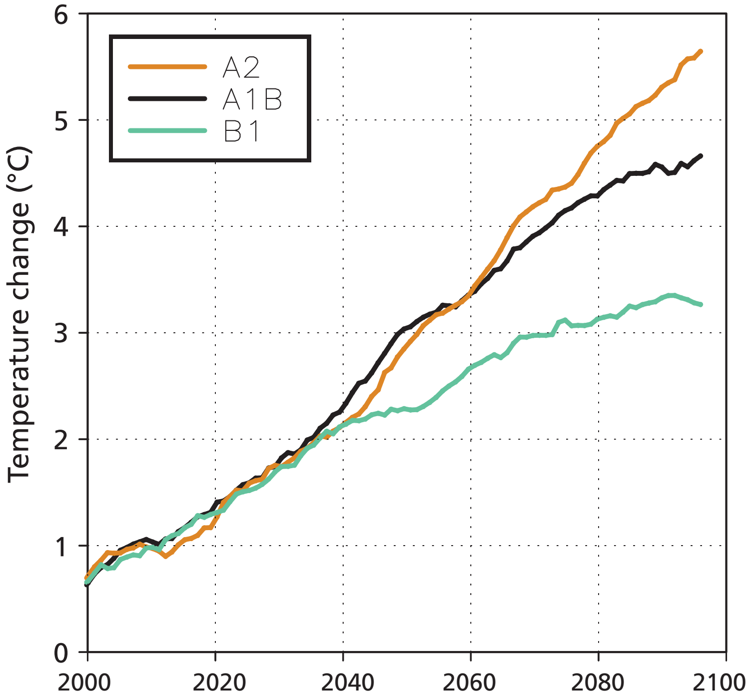
Other adverse effects of climate change, on the other hand, will only appear over a long time span. Sea level rise, for instance, will initially be slow, but it will continue for centuries. Preparations for long-term changes should be started well in advance. Some small island nations are already planning how they will relocate their population if the rising sea level renders their islands uninhabitable.

Societies are accustomed to preparing for different kinds of weather in the present climate. Climate change will have an impact on the severity and frequency of some extreme weather phenomena. Coping with these phenomena may well be more of a challenge than coping with changes in average temperature or precipitation.

How much warmer will Finland become?

In the course of the 20th century, Finland's average temperature rose by 0.7 degrees. In the future, the climate will become warmer and rainier. By 2050, the average temperature will rise by about two degrees Celsius. Both the warmer temperatures and the increased rainfall will be clearly more noticeable in winter than in summer.

Figure 8.2 Estimated trend in Finland's average temperature



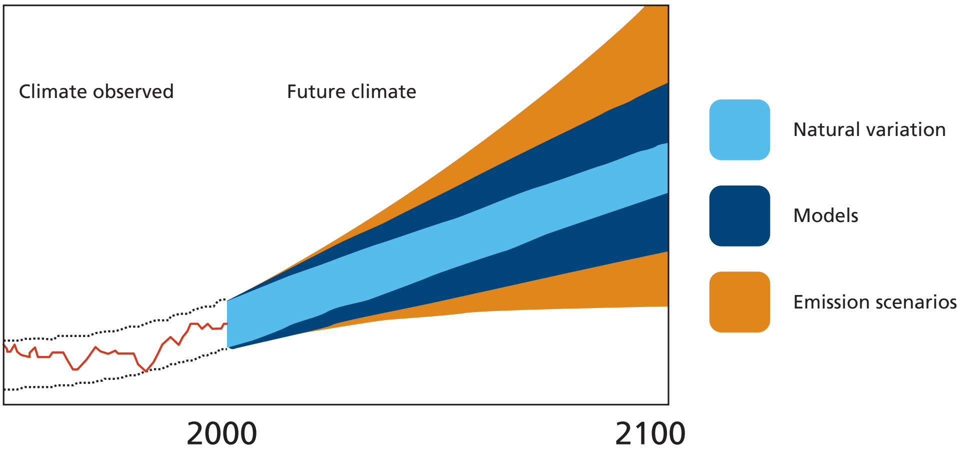
Estimated trend in Finland's annual average temperature during this century. In scenario A2, emissions continue to increase rapidly. In scenario B1, emissions are restricted effectively. Scenario A1B illustrates a mix between the two scenarios.

Source: Nevanlinna, Heikki (ed.). 2008. Muutamme ilmastoa. Ilmatieteen laitoksen tutkijoiden katsaus ilmastonmuutokseen [We are changing the climate. A review of climate change by researchers of the Finnish Meteorological Institute]. Karttakeskus. Porvoo, p. 138.

Warming will progress faster than average in the northern regions of the globe, including Finland. Even if global warming were limited to two degrees Celsius, the average temperature in Finland would still rise by about three degrees Celsius by 2100. If emission reductions are not achieved worldwide, Finland's temperature may rise by up to five degrees Celsius or even more.

The variation in the warming estimates for the next few decades is due particularly to natural variability in climate and to the differences between climate models. Policy effects will become increasingly important towards the end of the century. On high-emission paths, warming will be substantially quicker than on the low-emission paths.

Figure 8.3 Impact of uncertainty factors on estimates of temperature trends



The red curve shows the trend observed so far. The coloured areas describe uncertainties caused by different factors in future climate predictions.

Source: Räisänen, J. & K. Ruosteenoja. 2008: Probabilistic forecasts of temperature and precipitation change based on global climate model simulations (CES deliverable 2.2). p. 46.

In the rapid warming scenario, rainfall is estimated to increase by one fifth in the 2000s. On the low-emission path, the increase in rainfall may only be just over 10 per cent. There will be more rain particularly in winter, and these rain showers will be more severe and fewer in number.

Model calculations show that towards the end of the century, southern Finland may resemble the central Europe of today in terms of climate. Similarly, northern Finland would resemble the southern Finland of today. The comparison has its limitations, however, since the length of daylight hours, for example, will not change even though the climate grows warmer.

Box 8.1 Changing seasons

Global warming will significantly change the seasons as experienced in Finland during the current century.

- Thermal winter, i.e. the period during which the average daily temperature remains below zero degrees Celsius, will grow shorter and will no longer occur in southwestern Finland.
- In southern Finland, the shorter or disappearing winter will be replaced by a longer autumn. In the high-emission scenario, autumn may be lengthened by as much as two months.
- Summer and spring will grow longer more or less in equal measure throughout the country.
- The growing season will be extended by just under one month in the low-emission scenario and by about 1.5 months in the high-emission scenario, and by more than this in southwestern Finland.
- Floods will become more common in autumn and winter. On the other hand, there will be less spring flooding in southern Finland.
- The probability of dry spells in summer will increase.

Finland's climate is characterised by great variation. Cold winters and cool summers will continue to occur even with global warming.

Effects of climate change in Finland

The warming of the climate will bring both benefits and adverse effects to Finland. At moderate levels of warming, probable benefits include a longer growing season for agriculture, increased forest growth and less need for heating buildings as winters become milder. Production of bioenergy, hydropower and wind power is estimated to increase.

The quicker global warming progresses, the greater the adverse effects and risks are. Implications of worldwide damages caused by global warming will undermine or negate benefits in Finland. Also, some of the projected benefits are contingent upon our capacity for anticipating changes and adapting to them.

Hot summers will become more frequent together with mild winters, and more energy will be needed for cooling. Summer drought will become more common, and surface water and groundwater levels may drop at times. The benefits to agriculture and forestry may not be as substantial as expected, because the environment will also become more favourable to plant diseases and pests. Nutrient leaching during the winter thaw will increase, and eutrophication problems in water bodies will aggravate. The short daylight hours in autumn will erode the overall benefit of the longer growing season, and mild autumns and winters will make it difficult to work on fields and in forests (the surface soil can be soft and wet due to delayed freezing).

Some extreme weather phenomena will increase in number or in strength as the climate grows warmer. Precipitation will increase, and it will more often fall as heavy rain, making flooding more probable. On the other hand, there may be more periods of drought in summer. Storm damage to forests is estimated to become worse, since as the thaw lengthens, frost will no longer prevent trees from being uprooted.

Sea level rise may negate the land uplift along the Gulf of Finland by the middle of the century. At the same time, storms may increase the risk of flooding on the coast.

Global warming is estimated to increase the total number of species in Finland. For example, during the past decade more than 100 new species of butterfly and moth were observed in Finland. At the same time, however, many of Finland's present animal and plant species will become more endangered, particularly in the north. The tree line will move up, and dwarf birch shrubberies will become less common. Worldwide, the risk of extinction may increase by 40 to 70 per cent if global warming exceeds 3.5 degrees Celsius.

One of the most conspicuous changes in Finland will be that winter will no longer be cold and snowy in most of the country. Whereas between 1971 and 2000 there was a lot of snow in February and March every other year on average, by the 2030s the incidence of such winters may be 35 to 45 per cent in the north and only 25 to 35 per cent in the south. This means that winters will be darker, there will be fewer winter leisure activities, and the traditional image of Finland will change. For some people, the increased darkness may even increase the risk of seasonal depression.

For the indigenous Sámi people, climate change threatens their traditional way of life. It has already been noted that changes in weather and snow conditions are causing difficulties for reindeer husbandry, an essential part of Sámi culture.

Box 8.2 Climate change and insect damage in northern forests

Global warming will make living conditions better for many insect pests and may cause widespread forest damage. New pest species may spread to Finland from the south. The probable increase in the incidence of storms will make it easier for pests to attack the weakened forests. In Canada in the early 2000s, insect pests destroyed an area of pine forest equal to one third of Finland's forested areas.

Forest damage makes the mitigation of climate change more difficult. In cases of severe pest damage, as much as half of the carbon bound in the living biomass in a forest may be lost in ten years.

Insect damage can be controlled through forest tree improvement and removal of infested trees. However, some preventive methods, such as felling infested trees, may cause carbon emissions even greater than those caused by insect damage.

Adaptation in Finland

Successful adaptation is based on risk identification and targeted measures. In international terms, Finland was relatively early in conducting the first extensive studies on the impacts of climate change in the early 1990s. Adaptation research has followed impact research about ten years behind, but now preliminary adaptation assessments have been made in several sectors.

Finland is the first country to have drawn up a national strategy for adaptation to climate change. Adopted as part of the Government's National Energy and Climate Strategy in 2005, its key points are:

- initiating sectoral and cross-sectoral measures in public administration in the near future (2005–2015)
- adapting to changes elsewhere and international cooperation
- launching an adaptation research programme

In accordance with the strategy, adaptation issues are addressed in various sectors. For example, the Ministry of the Environment has drawn up an adaptation action plan for its administrative sector, and implementation plans have been drawn up in the administrative sectors of the Ministry of Transport and Communications.

Although Finland has been pioneering in this field, there is still scope for improvement. Key areas include the need to:

- increase awareness-raising and enhance participation in adaptation planning
- target specific measures at various sectors and develop practical tools to support decision-making
- strengthen horizontal approaches across administrative sectors
- enhance the international dimension and augment the evaluation of implications of global climate warming
- complement scientific and technical research with social and cultural studies

- improve cost estimates and increase research regarding the cost-effectiveness of various measures
- draw up regional and local vulnerability assessments and adaptation strategies
- study adaptation to the mitigation of climate change, including the impact of changes in the economic structure caused by emissions trading

Adaptation and mitigation measures can be mutually supportive but are occasionally contradictory. For example, during heat waves more energy is needed for cooling for health reasons; this increases energy consumption. On the other hand, the active cycling season may lengthen as the climate becomes warmer, which reduces emissions from traffic. When planning adaptation measures, links to mitigation measures must be considered – and vice versa.

Table 8.1 Impacts, adaptation needs and measures

	Impacts	Measures initiated	Long-term challenges
Agriculture	Earlier growing season, floods more common in winter and during harvest, price fluctuations greater	Research on plant cultivation oriented towards the needs of the changing climate, flood-sensitive arable land taken into account in planning, wintertime vegetation cover on fields encouraged	The changing role of Finland's agriculture as the world food security declines, breeding of new plant varieties, the prevention of plant diseases and pests, the increasing load on water bodies, flood protection and drainage for fields, irrigation
Forestry	Mild autumns and winters complicate the harvesting of wood	Improved monitoring of forest damage, improved preparation for storm damage	Limits of the adaptive capacity of forests in case warming is rapid, securing the wood supply for industry
Floods	Autumn and winter floods more common	Climate evaluations included in dam design and regulation of waters, risk assessment of floods in built areas improved, national land use guidelines revised	Preparation for rising sea level and flooding along the coast
Storms		Securing telecommunications, preparation for oil spills in the Gulf of Finland	Preparation for the combined effect of increase in storms and the rising sea level, preparation for forest damage
Energy		Impact of climate change on electricity grids assessed	Risks of bioenergy production, impact of increase in storms and the rising sea level on nuclear power plants, risks concerning major power lines
Transport	Mild winters complicate road maintenance and increase the risk of accidents	Adaptation studies on road, sea, air and rail transport, road districts have preparedness plans for disruption notification	Changes in the ice conditions of the Baltic Sea, logistical importance of northern Finland as the Northern Sea Route becomes passable
Buildings		Legislation and regulations developed to take extreme weather events into account	The need for cooling in energy-efficient construction
Health	Darker winters resulting from reduced snow and increased cloudiness, slippery road conditions more frequent	Finnish Meteorological Institute alert service for heatwaves and cold weather, study on correlation of weather and health problems	Coping with darkness
Tourism	Uncertainty of operations at winter sports centres, especially at the start of the skiing season		Alteration of winter sports centres in southern Finland, preparation for possible growth of tourism in eastern and northern Finland
Immigration		EU-level measures to control migration, combating illegal immigration and human trafficking	Preparation for uncontrolled forced migration

Adaptation is a worldwide challenge

Finland, like the other Nordic countries, is well placed by international comparison to adapt to the impacts of climate change. In many other countries, adaptation is much more of a challenge. The most difficult situation is in poor developing countries, in small island countries and in densely populated delta regions.

Development and adaptation to climate change are mutually supportive. The more advanced a society is, the better it is placed to prepare for the adverse effects of global warming and to compensate for them. Therefore, promoting human development in poor countries is not only a value unto itself, it is also vital for adaptation.

In agriculture, crop yields depend on the climate. At high and medium latitudes, agriculture with good adaptive capacity can benefit from climate change if it progresses moderately. In tropical and sub-tropical countries, by comparison, the situation is difficult to begin with because of factors such as drought, and the adaptive capacity is usually low. Under such circumstances, even a slight warming could significantly reduce crop yields.

Global warming aggravates extreme weather phenomena, making both floods and droughts more severe. The world's water supply will be highly vulnerable as the climate becomes warmer. About one sixth of the world's population lives in areas where the availability of fresh water will decline during the current century as mountain glaciers melt.

The International Red Cross has estimated that, in ten years, the number of people suffering from natural disasters has tripled to about two billion. This figure reflects above all the vulnerability of communities, but climate change also worsens the effects of natural disasters caused by extreme weather phenomena.

Climate change can radically worsen living conditions, and the resulting forced migration and disputes concerning water supplies, for example, may give rise to violent conflict. Legal and illegal immigration to Europe will probably increase as climate change progresses. This will be reflected in Finland, too.

Tourism within Europe, from the north to the Mediterranean, constitutes the greatest single flow of tourism in the world. This situation may well change towards the end of this century, as Mediterranean summers are expected to become intolerably hot. The attractiveness of the Alps as a skiing destination will also decline as the snow line moves upwards with global warming.

At the same time, the summer tourism season in Finland will lengthen, and snow cover will still be on the ground for most of the winter in the north of the country; taken together, these facts will improve Finland's relative status as a tourist destination. On the other hand, emissions restrictions on air traffic may slow down the growth of long-distance travel.

The opening of the Northern Sea Route (Northeast Passage) will cut shipping distances between Europe and Asia to about one half of the present. The economy of the northern parts of Russia is likely to grow as the climate becomes warmer, generating new opportunities in northern and northeastern Finland, too. The competition for natural resources in northern sea areas may lead to increased international tension, and the risk of environmental damage will also grow.

The greatest impact of climate change on Finland will probably come in the form of repercussions from elsewhere in the world. If the food shortage gets worse, poverty increases and millions of people are forced to leave their homes because of the adverse effects of climate change, this will inevitably have a negative impact on Finland as well.

Costs of adaptation

Adaptation to the impacts of climate change will require substantial additional investment. According to an estimate by the UN Development Programme, USD 86 billion will be needed in adaptation funding in 2015 alone.

Table 8.2 Need for global additional investment in adaptation in 2030, by sector

Sector	Cost (USD billion)	Percentage in developing countries
Agriculture, forestry and fisheries	14	50
Water supply	11	80
Health	5	100
Coastal protection	11	45
Infrastructure	8–130	25

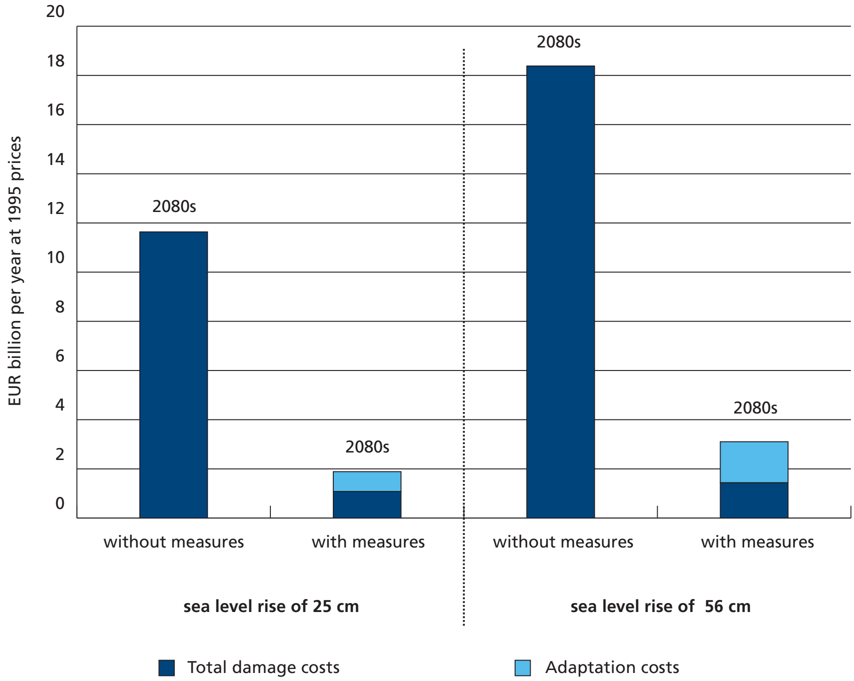
Cost in US dollars at 2005 level.

The European Commission has estimated that the discounted costs of unmitigated climate change to 2200 would amount to about EUR 74 trillion (thousand billion). These costs would be approximately halved if global warming were mitigated to 2–3 degrees Celsius. There is great uncertainty in these estimates, and the evaluation did not include the option of cutting costs through adaptation.

The UNFCCC Secretariat has estimated that total adaptation costs for all developing countries may amount to EUR 23 to 54 billion per year by 2030. Many measures, if implemented early, may result in a net gain for the national economy. This applies, for instance, to measures to improve the efficiency of water use in areas suffering from a water shortage.

More detailed estimates on the costs of adaptation are available mostly on a regional and sectoral basis. The costs of coastal protection and preparation for flooding are the best known. It is estimated that the money invested in adaptation will be recouped many times over in benefits to society.

Figure 8.4 Costs caused by the rising sea level, with and without adaptation measures



The estimates are based on SRES scenario A2 of the IPCC.

Based on European Commission. 2007. Adapting to climate change in Europe – options for EU action. COM(2007)354 final. Brussels, 29 June 2007, p. 10.

For example, the UK intends to invest more than USD 40 billion in adaptation projects such as air conditioning for the London Underground and the mitigation of flood damage. Australia has earmarked about EUR 13 billion for drought relief. In the Netherlands, the additional costs for coastal protection caused by climate change are estimated at EUR 1 to 2 billion per year until the end of this century.
In Finland, estimation of adaptation costs is only just beginning. Preliminary reports show that it is believed that the direct impact of global warming will be only slightly negative in Finland in the short and medium term, or perhaps even positive. If, however, the warming is quicker than predicted or the major risks related to climate change are actualised, the costs may be substantially higher. The costs will also rise if the global repercussions – not included in current estimates – are taken into account.

Extreme weather phenomena and the instability of their impact will probably cause more costs than those arising from gradual or average impact. Consecutive dry summers, mild and rainy autumns or repeated heavy rains may severely stretch the adaptive capacity of some sectors.

The insurance sector worldwide is developing derivatives related to weather phenomena and climate change so that farmers can insure themselves against extreme weather. Micro-insurance is already in use in pilot projects in developing countries, and new risk management methods are being developed. The European Commission is involved in the piloting of systems to provide support in the event of climate-related disasters.

Box 8.3 The urban flood of Pori, 2007

In late summer 2007, the city of Pori received one fifth of its entire annual rainfall within three hours. The damages caused by the rain flood are estimated at about EUR 20 million.

The likelihood of flooding is increased not only by rains being augmented by climate change but also by the rising sea level and the impact of global warming on snow melting and the flow rate in rivers. Winds can also influence floods. Summer and autumn flooding is predicted to increase the most in Pori, their likelihood increasing by one third or even two thirds. In a worst-case scenario, a major flood would force the evacuation of 15,000 people from Pori.

Floods caused by rainfall are more difficult to prepare for than flooding rivers or coastal flooding. The city of Pori has prepared for future floods, for instance, by improving flood anticipation, making preparedness plans, repairing banks, dredging channels and guiding land use policy.

Preparations must be made even for extreme warming

If emissions continue to grow at a rapid rate, the world's climate may warm up by more than four degrees Celsius. We cannot exclude the possibility that global warming may even exceed six degrees Celsius during the current century. This would mean that the average temperature in Finland would rise by nine degrees Celsius by the end of the century, and by even more in winter. The impact of such rapid warming would be extremely negative and partly unpredictable.

There is little research on very rapid warming. The Tyndall Center in the UK has evaluated sudden and severe changes in the climate system, such as the shutdown of the thermohaline circulation in the Atlantic Ocean, a rapid increase in average temperature and permanent changes in rain patterns in the southern hemisphere (El Niño).

All of these would have profound global impacts. Ecosystems and the food supply would decline. Increased droughts and floods could cause widespread damage.

The food and energy crises thus caused could be extremely severe. In many cases, a decline in living conditions would force large numbers of people to flee to new areas.

Research in Finland focuses largely on the effects of global warming that progresses moderately and steadily. However, because the possibility of sudden rapid warming cannot be excluded, the risk scenarios of extreme and non-linear climate variations must also be explored.

Adaptation to rapidly progressing warming has not been studied much, either. From the risk management point of view, preparation for exceptionally severe change is justified.

Box 8.4 Effects of climate change on the Baltic Sea

Warming will cause many changes in the Baltic Sea. Species will probably migrate towards the north, and invasive species will become more common. The flow of fresh water is expected to increase so that the average salinity of the Baltic Sea will drop, perhaps to as much as half its present level. Many of the species dependent on the current level of salinity will migrate elsewhere or decline.

If nutrient leaching into water bodies increases, eutrophication may speed up. Higher temperatures mean more algae blooms. An increase in rainfall may mean less salty water flowing in through the straits of Denmark, leading to widespread anoxia on the sea floor. Anoxic conditions and eutrophication would significantly change the living environment for marine species and weaken the fishing conditions.

Ice cover in the Baltic Sea in winter is expected to shrink by 50 to 80 per cent, and the freezing of the sea is expected to be delayed by about one month on the coast of Finland. Less ice makes conditions better for shipping, but increased winds and storms due to climate change can also hinder it.

The Government’s policies

- Finland aims to continue to be a leader in adaptation. Adaptation is integrated into all sectors, and cross-sectoral cooperation is enhanced.
- Risk assessment methods are developed, and risk assessments are enhanced. Potential for adapting to climate change more severe than predicted will be explored.
- The indirect impacts of worldwide climate change on Finland will be studied. A comprehensive estimate of adaptation costs will be drawn up.
- Adaptation is integrated more closely in development policy, and the adaptation of low-income developing countries will be supported. Finland is committed to bearing its own fair share and responsibility for adaptation funding.
- Tools are developed and provided to local authorities together with support for adaptation measures.

9 TOWARDS MORE EFFECTIVE POLICIES AND MEASURES

The price of climate protection can be cut by selecting cost-effective policies and measures. Economic measures, such as emissions trading and taxes, have proved to be efficient in many cases. However, the whole range of measures should be put to use: incentives and disincentives, steering by norms and information, as well as financial measures. Policies and measures can also be modified to increase their effect. Good steering can support innovations and the adoption of technology.

Transition to a low-carbon society requires a resolute policy that substantially strengthens and intensifies the current means of steering. Some completely new policies and measures must also be adopted. The long-term goal is a society where low-carbon solutions have an established position and the need for separate climate policy measures is minimised.

Good steering is typically

- coherent and sustained: actors can prepare for the changes envisaged
- consistent: it can be trusted that decisions will hold, and various measures support each other
- effective: steering brings significant benefits
- cost-effective and market-based: the benefits are obtained at reasonable costs
- technology-neutral: a target is set through steering, and detailed technical solutions are left for actors to decide

The policies and measures adopted must support sustainable development and take global repercussions into account. Reducing emissions in one place must not lead to increased emissions somewhere else. Emission reductions must also be certain and lasting.

Policies and measures can be divided roughly into discouraging and encouraging, i.e. sticks and carrots. Examples of measures that have a discouraging effect include restrictions, taxes and fees. In contrast, awareness-raising, subsidies and tax reliefs have an encouraging effect. Both are needed.

Emissions can also be curbed at many different levels: locally, regionally, nationally, at EU level and internationally. The most suitable level depends on the nature of the issue at hand. For example, it is reasonable to decide on emission restrictions concerning international transports at international level, whereas matters pertaining to transports within a country are easiest to handle nationally.

Lack of actions at the ideal level must not be an excuse for inaction. Whenever necessary, countries and municipalities with leading roles in climate protection must be able to adopt stricter measures than those taken at the higher level. Even though the EU plays a crucial role, Finland can still make national decisions about a great many policies and measures. Finland can also contribute to the development of solutions that other EU Member States can learn from and set an example to the rest of the world.

Intelligent policies and measures

The selection of a steering measure is important, but sometimes it is even more important how that measure is implemented. Even a weak steering measure, when well planned and implemented, can be better than a good steering measure that is poorly planned and implemented. For example, the feed-in tariff for renewable energy can be implemented on market terms and cost-effectively, or in an inflexible and expensive way.

Traditionally, policies and measures have been fairly straightforward and simple; for instance, a tax determined as a percentage or in euros per taxable unit. In contrast, effectively targeted policies and measures which minimise the negative side effects can be considered intelligent.

The car tax is a good example. The tax used to be the same percentage of the sales price irrespective of how much the car burdened the climate. The reform that came into effect at the beginning of 2008 differentiated the car tax according to the emission level, encouraging the buyer to choose a car with low emissions. The reform cut the average emissions of new cars sold by nearly one tenth. Differentiation made a rather poorly targeted instrument more intelligent in terms of climate protection.

The effectiveness of other policies and measures can also be improved. For example, working groups are examining whether real estate taxation can be differentiated according to the energy efficiency of the building and whether differentiated excise duties on fuels based more effectively on carbon content can be introduced. This way, while the taxes are targeted differently, the overall sum collected through taxation remains unchanged. Consequently, it is possible to achieve substantial climate benefits at a public net cost of zero euros.

Steering has often been applied bit by bit, like a mosaic. Under such circumstances, the effect of individual steering measures may have remained modest. The best steering effect is typically obtained by means of comprehensive steering that combines a wide spectrum of mutually supporting actions. Thus, the combined effect may be greater than the sum of its parts. One steering measure may also have several impact mechanisms; for instance, differentiating a tax may also include an information element.

New policies and measures can first be tried out, to test their functionality in practice; if any problems should arise, solutions to them can then be sought. Trials make it easier for people to participate in public debate and they lay the foundation for scientific evaluation. For example, the congestion charges in Stockholm were initially implemented as a fixed-term experiment and the subsequent effects were analysed thoroughly. The experiment was followed by a referendum where the majority expressed their support for making the charges permanent.

More with less

As a rule, climate protection should be as cost-effective as possible. This means that the climate benefit sought is achieved at the least possible cost to society. Cost-effectiveness can also be examined from the reverse angle: the same cost should maximise the climate benefit. This may make it politically feasible to accept more stringent emission targets.

The cost-effectiveness of various policies and measures varies considerably. There can be differences of up to several orders of magnitude in climate benefits achieved per public investment. By compiling a sensible set of policies and measures, the costs of emission reductions can be minimised and the benefits maximised. The costs of various policies and measures may also affect population groups and enterprises in different ways; this should be taken into account when planning policies and measures.

The most cost-effective way to reduce emissions is to improve energy efficiency in all sectors. It is also estimated that opportunities for emission reductions at reasonable costs exist, in particular, in agriculture and forestry and in waste management. Cost-effective steering measures include the steering of public procurement, and the differentiation of energy and real estate taxes as well as taxes associated with driving.

Typically, the most cost-effective steering measures are catalytic and create markets. Examples include competitive tendering in the field of innovative technology and harnessing of public procurement. Traditional volume subsidies, such as tax and investment subsidies, that spur emission reductions by supporting the selected activities with direct public money are more expensive. In such a case, a major public investment is required to achieve a great impact, and the government's capacity and willingness to pay set the limit for rapid and far-reaching results. Moreover, the use of state subsidies is restricted by EU rules.

An evaluation of cost-effectiveness depends on how the limits of the review are set. If various ancillary benefits are taken into consideration, solutions that at first seem expensive may prove to be economically advantageous to society.

For example, many solutions that cut emissions caused by transport also reduce traffic congestion, noise, accidents, and the need to invest in new infrastructure. The more comprehensively ancillary effects are taken into consideration, the more advantageous the solutions often prove to be.

Often the most advantageous way to reduce emissions in the short term is to use technology that is already mature. However, this does not encourage the development of new technology. Input into technology can be seen as an investment that lowers the costs of future emission reductions. Germany's investments in solar power production have been expensive, but they have helped commercialise technology that may play a key role in the reduction of global emissions in the long term. In Finland, too, new technology can be commercialised and export opportunities can be created through timely steering.

Scarcity of information is another factor hampering the implementation of cost-effective policies. In Finland, the efficacy and cost-effectiveness of various policies and measures have so far been studied only little. Thus, climate policy has had to be formulated partly without comprehensive knowledge of its direct and indirect effects. This may have contributed to the impression that emission reductions are expensive.

Differences between countries make international comparisons difficult. Mechanisms that have been found to be good in some countries do not necessarily work equally well in Finland. Similarly, mechanisms that used to be effective are not necessarily equally effective at a later time. On the other hand, some mechanisms may work better.

Right price for emissions

Nicholas Stern, former Chief Economist of the World Bank, has characterised climate change as the greatest market failure of all time. The current volume of emissions is too great from the viewpoint of economics, because the external costs caused by climate change are not reflected in the prices of products and services. In other words, emissions can be generated without paying their real costs to society; the bill for the adverse effects of emissions is left for someone else to pay.

External costs can be included in prices through economic steering measures in many different ways. Many economists recommend emissions trading, provided that the system is as comprehensive as possible and the price signal is not distorted for political reasons.

In emissions trading within the EU, a cap is set for the total emissions of the sectors involved. Companies must acquire enough emission allowances to cover the emissions they produce; these allowances can also be bought and sold. In this way, trading directs the parties to reduce emissions where it is the most cost-effective; this brings down the overall costs of climate protection.

The most commonly offered alternative to emissions trading is the carbon tax. The impact mechanisms of trading and the tax are largely the same: choices burdening the climate become more expensive, while choices protecting the climate become relatively less expensive. Both methods can also be used to collect income for climate action if emission allowances are auctioned off in the trading system.

There are differences, too. In the prevailing emissions trading systems, the desired emission level is fixed and markets determine the price of emissions, whereas the tax is used to set a price for emissions, after which markets determine the emission level. So far, setting international environmental taxes has proved to be both time-consuming and politically extremely difficult.

Systems for emissions trading between companies are in use or about to be adopted in most industrialised countries; they are also being planned elsewhere, for instance in Taiwan and South Africa. In addition, the Kyoto Protocol enables emissions trading between industrialised countries.

The systems must be linked, expanded and deepened to facilitate a gradual transition to global emissions trading that is as comprehensive as possible. According to an objective presented by the Council of the European Union, the emissions trading systems of OECD countries should be linked together by 2015, and the systems of the wealthiest developing countries by 2020.

For linking, systems need to be comparable with respect to their requirements and their key properties. Linking may proceed stepwise so that the most compatible parts are linked first. Whenever necessary, emission allowances can be converted using coefficients in the same way as in currency trading.

In the emissions trading sector, the system itself is in principle enough to guarantee the necessary emission reductions, if it is equipped with sufficient monitoring and sanctions. Other policies and measures may, however, be needed to reach parallel goals, such as improved energy efficiency and commercialisation of innovative technology. Nor does emissions trading cover all emission sources and greenhouse gases.

Table 9.1 Emissions trading systems in use or under preparation

System	Region	Status	Period
EU emissions trading	27 EU Member States and Norway	in force	2005–
New Zealand	New Zealand	in force	2008–
Regional Greenhouse Gas Initiative (RGGI)	Ten Northeast and Mid-Atlantic states in the USA	in force	2009–
Canada	Canada	under preparation	2010–
Australia	Australia	under preparation	2010–
UK	Certain sectors outside EU emissions trading	under preparation	2010–
California	State of California	under preparation	2012– (preliminary)
Western Climate Initiative (WCI)	Seven Western states in the USA and four provinces in Canada	under preparation	2012–

Box 9.1 Emissions trading within a country

Emissions trading can also be used for targeting emission reductions within a country. In practice, trading can be organised in various ways; for instance, the government may have a standing purchase offer for emission reductions. At any single time, the government would purchase the most economical verified emission reductions offered by municipal and corporate projects.

Emissions trading within a country is economically attractive in a situation where the country is a net buyer of emission units and the price of emission reductions purchased abroad is high or their availability is uncertain. The system may facilitate emission reductions outside the emissions trading sector. A prerequisite is that the system can be made to work efficiently.

The Swedish Klimp programme has financed the climate projects of municipalities, provinces and enterprises in energy, waste and transport sectors. Ministries have carried out the projects together, and a council appointed by the Government has made the decisions. The programme has enabled emission reductions of over one million tonnes per year since 2003.

In France, 20 pilot projects have been identified outside the emissions trading sector; these could cut emissions by about six million tonnes. The projects would be funded by means of Joint Implementation of the Kyoto Protocol. The estimated potential is about 10–15 million tonnes, especially in building and agriculture. In Finland, too, it may be justified to reduce emissions through the Joint Implementation mechanism.

The euro is often a good consultant

In many cases, the price signal is efficient for guiding behaviour. When solutions burdening the climate become more expensive, people are motivated to reduce their use and to choose more sustainable solutions. The euro is often a good consultant, especially when it is combined with other steering measures, such as awareness-raising.

The strength of economic steering is that it leaves the freedom of choice to the actors themselves. For instance, it is not necessary to prohibit the sale of fuel-guzzling SUVs if people are encouraged to favour more energy-efficient alternatives through taxation. Consumers still have the option of choosing a heavily emitting car if they consider it important enough and have the money for it.

Many policies and measures primarily strive to promote goals other than climate policy, but they may also have direct or indirect impacts on emissions. Policies and measures must be evaluated and, whenever necessary, adapted so that important social objectives can be reached in ways that are as conducive to climate protection as possible. However, reducing emissions cannot be the only criterion for weighing the acceptability of policies and measures.

According to the OECD, for example, the following policies and measures have direct or indirect impacts on emissions:

- car benefits and tax deductions for the expenses of commuting by car
- exemption of peat from excise duty, and the feed-in tariff of peat-fired condensing power
- lower electricity tax rates for industry and greenhouse cultivators
- tax-exempted fuel for air and sea traffic in Finnish territory
- subsidies for ship traffic and for goods transports in sparsely populated areas
- energy tax subsidies for agriculture and market gardening
- tax refunds for energy-intensive enterprises
- exemption of private landfills from the waste tax

Legislation and taxation also have some relics that slow down the reduction of emissions. Policies and measures must be worked over from the perspective of climate protection, and obstacles to emission reductions must be eliminated. The Ministry of Finance has already launched the evaluation of the tax system from this angle.

After emissions trading was introduced, the need to use taxation as a means of steering greenhouse gas emissions in the emissions trading sector has reduced. In 1998–2007, the share of environmental taxes in the GDP fell from 3.3 per cent to 2.7 per cent. However, taxes are still needed, especially in other sectors and applications. Besides climate policy objectives, environmental taxes have other, e.g. fiscal, objectives.

Prime Minister Vanhanen's second Cabinet has decided to implement the largest ecological tax reform to date by shifting the emphasis from the taxation of work to the taxation of activities burdening the environment. The scope of this reform is about one billion euros. The ecological tax reform must be continued in the long term. The goal must be set so that the steering effect of taxation on emissions outside the emissions trading sector is at least of the same order as the effect of emissions trading. It is worth developing the current taxes further to improve their steering effect on the climate; and whenever necessary, new taxes must also be considered.

As emission targets are rapidly becoming stricter, it is important to strike a balance between the use of the stick and the carrot. Resorting only to restrictions and fees would undermine public approval of climate protection. Even though the Finnish budget practice does not allow direct earmarking, the auctioning of emission allowances brings the State revenues that can be used to support sustainable solutions.

In some cases, economic steering may increase inequality. If money can be used to purchase permission to burden the climate, high-income groups can continue to produce a lot of emissions. Taxes and fees based on consumption may also be regressive; i.e. they may have a relatively greater effect on low-income groups.

Social disadvantages can be avoided by compensating for the additional costs, for instance, through income transfers and by targeting the steering measures more effectively. One of the ideas presented is that the electricity tax payable by households should be differentiated according to consumption. The tax per capita could be fairly low at the basic level; for consumption exceeding this level, the tax would rise gradually. Similar differentiation could be considered for taxes and subsidies applied to housing and traffic.

Box 9.2 Steering by norms

Steering by norms is particularly well suited to applications where the price signal is not effective enough or not correctly targeted. For example, few consumers consider energy efficiency to be an essential criterion when selecting a digital set-top box, because the energy consumption of an individual device is hardly noticeable in the electricity bill. In such a case, the simplest way is to set norms for the maximum consumption of the device.

In Denmark, effort has been made to promote the energy efficiency of buildings by a three-step programme:

1. less: the most inefficient building practices are removed from the market by means of norms
2. more: efficient building practices are favoured, e.g. by means of incentives and information
3. better: the best solutions are promoted, e.g. by means of demonstrations and acquisitions

Feed-in tariffs for renewable energy

During the past decade, feed-in tariffs have become an increasingly common practice worldwide for promoting renewable energy production. These tariffs guarantee an extra price or a guaranteed price for green electricity. The system is in use in approximately 40 countries throughout the world, including 19 EU Member States.

Feed-in tariffs have been scaled according to the type of energy so that new technologies receive higher support while mature technologies receive less. In this way, different technologies can be promoted in a tailored manner without major over-compensation. The tariff may decrease over time; this encourages operators to create more efficient technologies and to commercialise them.

The extra price is collected from electricity users, and it can be scaled according to the user type. For example, the price collected from energy-intensive export industries may be reduced in order to minimise disadvantages to competitiveness.

In Germany, the use of tariffs has tripled the production of renewable electricity during the 2000s. Estimates of the costs of the tariffs vary; initial investments in new technology are fairly expensive, but in exchange the industry in the sector has boomed. According to the Federal Environment Ministry of Germany, by 2006 the tariffs had increased the number of new jobs by 70,000 net, even when the decrease in purchasing power caused by higher electricity prices is taken into account.

In Finland, feed-in tariffs were first taken into use for peat-fired condensing power in order to secure the position of peat in competition against imported coal. According to the Government's Long-term Climate and Energy Strategy, the scope of the tariffs will be extended to encompass some of the electricity produced with renewable energy. A cost-effective tariff system operating on market terms is planned and dimensioned so that it will lead to a sufficiently rapid increase in renewable power production.

In most countries, the tariffs apply to all major forms of renewable energy. In Finland, too, they should have sufficient coverage and steering effect with regard to the targets relating to renewable energy. From the perspective of long-term challenges, it is important that the tariffs enable rapid deployment and diffusion of new technologies.

Road user and congestion charges

Another steering measure that has recently become increasingly common worldwide is the adoption of road user charges to curb driving. The aim of road user and congestion charges is to reduce driving and the associated harmful effects, to level off peak-hour traffic, to promote public transport, and to finance transport projects. These charges are applied in dozens of countries the world over.

The charges may apply to the entire road network or a single urban area, only to heavy traffic or all road traffic. They can give road users a signal of the costs of driving to society; this directs them to make more sustainable mobility choices. They can also affect people's traffic behaviour more effectively and in a more targeted manner than general taxes.

The term congestion charge usually refers to charges collected locally in urban areas. Typically the charge is collected from people who drive to the central city zone during daytime on weekdays. In Stockholm, congestion charges reduced driving by one fifth during the trial period, although traffic volumes have again increased slightly after the system became permanent.

Road user charges usually refer to charges that are collected more widely on the basis of car use. In the Netherlands, a charge based on satellite positioning will be taken into use for all road traffic in phases during 2012–2016. A charge determined by the kilometres driven replaces taxes associated with the ownership and purchase of a car; it is differentiated depending on time, place and the vehicle's emissions.

So far no road user or congestion charges have been adopted in Finland. A working group within the Ministry of Transport and Communications is studying the possibilities of applying charges based on zones or satellite positioning in the Helsinki region. In heavy traffic, lorries will be subject to a vignette charge.

By means of satellite positioning, the charges can be scaled according to time and place. Technology makes it possible to collect higher charges in areas where the adverse effects of traffic are the greatest and the alternatives to driving are the most numerous. The system of charges can be implemented without compromising privacy protection.

When the charges are scaled according to the car's emission level, people are encouraged to choose electric cars and other vehicles with very low emissions. If these charges replaced some of the taxes levied on cars and driving, it might even be possible to reduce the costs incurred by drivers in remote areas without compromising environmental steering in any essential way. In this sector, too, new technology can offer Finnish companies opportunities for exports.

In the future, charges based on positioning will provide interesting possibilities also in Finland. We must therefore be prepared to adopt them when the technology is sufficiently advanced and the costs are reasonable. In practice, transition to the system should take place in steps and through pilot projects. The necessary studies and pilot projects must be launched in good time so that the charges can eventually be taken into use.

Box 9.3 Personal emissions trading

There has been debate in the UK on whether emissions trading could be extended to the level of individuals. The advantage of personal emissions trading is that the system makes climate restrictions tangible to everyone and links daily choices to the available carbon budget.

The model would also be socially equitable and encouraging. Everyone would be given equal emission quotas, and people who burden the climate less could sell their unused emission allowances. Similarly, people who burden the climate more would have to pay extra.

There are no technical barriers to personal emissions trading. However, the system is likely to be very expensive. According to estimates made in the UK, the price could rise to 1–2 billion pounds.

Personal emissions trading could initially be tested in stages, for example by starting with voluntary and local systems. At first it is reasonable to only include the elements that are the easiest to measure: electricity, heat, transport fuels and flying.

The public sector must set an example

The public sector must do its share and set an example in emission reductions. In this way, it can better inspire households and companies to join the common effort for the climate.

In Finland, the public sector spends about 15 per cent of the GDP, or EUR 27 billion, for purchasing services and products. Three quarters of all public procurement takes place in municipalities; the State accounts for the remaining one quarter. It makes a big difference whether these billions of euros are used for solutions that protect or burden the climate.

The Government Resolution on Sustainable Procurement sets several targets for public procurement. In new buildings and in the renovation of old buildings, the first target is to reach a low energy level, and as of 2015 the target will be passive buildings. The aim is to reduce goods transports by one tenth and increase the use of green electricity. Institutional kitchens will favour organic and seasonal foods and vegetarian food.

Climate-friendly procurement calls for target-oriented procurement policies and strategies. Procurement must be based on the life cycle approach, where climate impacts are taken into account from start to finish. Procurement units must have sufficient know-how, and they must be able to obtain information on the climate impacts of their acquisitions and on sustainable alternatives. Sustainable procurement can be supported by setting up a national advice point and by providing service on the Internet free of charge.

Many countries have set targets for increasing the share of sustainable procurement. In the Netherlands, environmental criteria must be used in all procurements by the State as of 2010 and by municipalities as of 2015. Denmark has introduced compulsory sustainability criteria for 14 product groups procured by the State.

Public procurement can also promote the commercialisation of innovative technology. In technology competitions arranged in Sweden, the Swedish Energy Agency first assesses the possibilities of developing products such as heat pumps, refrigerators or light fixtures. Then the agency gathers a group of procurers interested in the sustainable solution, launches a competition and evaluates the tenders. The winning entry gets publicity and an order from the procurement group. Thus, the more sustainable product gains rapid access to the market.

The Government's policies

- Climate policy steering must be coherent and sustained, consistent, effective, cost-effective, and technology-neutral.
- Research on the cost-effectiveness of climate policy is increased. Effort is made to consider all direct and indirect effects of steering, in both the short and long term.
- The linking, deepening and expansion of emissions trading systems are promoted, while ensuring their effectiveness vis-à-vis the climate. The goal is to introduce comprehensive and global emissions trading.
- The current public policies and measures are evaluated from the perspective of climate protection, taking into account other social objectives. Policies and measures leading to emissions are reduced and revised.
- The long-range ecological tax reform is continued. The target is that the steering effect on emissions outside the emissions trading sector is at least of the same order as the effect of emissions trading.
- A balance is sought between incentives and disincentives. Households and enterprises are encouraged to choose sustainable solutions.
- Feed-in tariffs and other economic steering measures are implemented so that they are comprehensive enough in view of the goals to increase renewable energy. Steering measures are planned so that they help commercialise new technology.
- In transport, the focus of economic steering measures is shifted to car use. The future adoption of road user charges based on satellite positioning is explored. These charges would be scaled depending on the time, place, and the emission level of the vehicle.
- The public sector must set an example in climate protection. Procurement units are required to draw up strategies showing how climate issues are considered in procurement.
- The role of public procurement in the commercialisation of sustainable technology is investigated. Realisation of sustainability in procurement is monitored and reported regularly. The need to revise legislation in order to promote climate-friendly procurement is explored.

10 MAINSTREAMING CLIMATE POLICY

Transition to a low-carbon society requires that the climate perspective is mainstreamed into all policies. The climate perspective must be included in decision-making in every sector and at all levels. Many structures and practices must be revised and sufficient evidence-based information obtained to support decision-making. Municipalities and the regions must also be involved in the joint effort more actively than at present.

Societies have many goals which often support each other: well-functioning transport supports the economy; education supports equality; development cooperation supports security. However, sometimes different policies may be left without a common link or may even work against each other. Good objectives in one sector may have led to a situation where other objectives are jeopardised.

The goal in mainstreaming climate policy is that climate objectives are taken into account and supported in all policies. Actors whose main tasks are not associated with mitigating climate change or adapting to it should also be involved. Even though the climate can in principle be mainstreamed in all sectors and at all levels, it is justified to concentrate on the most important operations, such as solutions concerning energy, transport, land use and food.

Mainstreaming can strengthen climate policy in two directions. Horizontal mainstreaming supports the consideration of climate issues in all public administration and in all sectors. Vertical mainstreaming means the integration of climate issues in each branch of administration at all levels, from local to national.

The target of mainstreaming is to avoid unnecessary policy conflicts and to consolidate synergies between activities. By contrast, mainstreaming does not strive to bypass other social objectives. The minimum requirement is that decision-makers have enough information about the impacts of various policies so that conflicting objectives can be prioritised. To be successful, mainstreaming calls for know-how, resources, commitment, monitoring and evaluation as well as the ability to deal with conflicts between climate policy objectives and other objectives.

The severity of climate change is generally acknowledged today. In practice, the severity of the issue must be made visible in political priorities and decisions. Transition to a low-carbon society will be one of the greatest shifts ever experienced, and the changes lying ahead require political leadership. The Government, ministries, and other upper management of State administration must be consistently committed to advancing climate protection in all activities.

Structures to meet today's needs

Most present-day institutions, decision-making processes and practices were created before concern for the climate heightened. It is necessary to consider how processes and practices could be developed so that they would better support the transition towards a low-carbon society. When solutions are considered, the goal should be efficiency and elimination of overlapping and unnecessary structures.

In practice, decisions concerning or affecting the climate are made in every ministry. The Ministry of Employment and Economy, the Ministry of the Environment, the Ministry of Transport and Communications, and the Ministry of Agriculture and Forestry are responsible for policies that have the most direct impact on emissions. The Ministry of Finance, responsible for taxes and appropriations, also plays an important role.

Table 10.1 Ministries' roles in relation to the mainstreaming of climate policy

Ministry	Responsibility in climate policy	Policies associated with the climate
Prime Minister's Office	Coordination of the Government Programme, the Foresight Report	
Ministry for Foreign Affairs	Clean Development Mechanism projects	Foreign and security policy Development policy Trade policy
Ministry of Justice		General guidance of legislative drafting
Ministry of the Interior		Rescue services Steering of regional planning
Ministry of Defence		Security policy One quarter of public procurement
Ministry of Finance		Central government finances Steering of government procurement Energy taxes and subsidies Other policies concerning taxation and subsidies Municipal structure
Ministry of Education		Education policy Research and science policy One fifth of public procurement
Ministry of Agriculture and Forestry	Main responsibility for adaptation to climate change	Agriculture and forestry Water supply and water resources Food
Ministry of Transport and Communications		Transport policy Transport routes One fifth of public procurement
Ministry of Employment and the Economy	Main responsibility for the mitigation of climate change	Energy policy Emissions trading Industrial policy Technology and innovation policy Steering of public procurement Labour market functions
Ministry of Social Affairs and Health		Environmental health
Ministry of the Environment	Main responsibility for international climate negotiations Joint Implementation projects	Urban planning Construction Waste management Environmental legislation, incl. permits General steering of sustainable development

Some countries have decided to revise the sectoral responsibilities of ministries and ministers in order to strengthen the climate perspective and to ensure coherence. In Denmark, for instance, a Minister of Climate and Energy has been appointed to assume responsibility for climate policy (shifted from the Ministry of the Environment) and energy policy (shifted from the Ministry of Transport and Energy). France is planning to set up an expanded ministry for the environment and sustainable development, which will also encompass the Ministry of Transport and some sections of the Ministry of Industry.

In Finland, the Ministerial Working Group on Climate and Energy Policy and the network of representatives from relevant ministries have so far been the principal bodies ensuring the coordination of climate policy. At the outset of his second Cabinet, Prime Minister Matti Vanhanen appointed a Government Climate Policy Specialist to the Prime Minister's Office. Similar specialists have been appointed to the staff of the prime ministers, presidents or federal chancellors in many other industrialised countries as well. The importance of climate policy will keep increasing in the future, and means of coordination will have to be considered against this backdrop.

The preconditions for climate protection depend crucially on the State budget because it determines issues such as energy and environmental taxes, subsidies to renewable energy and public transport, and appropriations for transport projects and information campaigns on the climate. However, it is rather difficult to see which items on the budget book are linked with the climate directly or indirectly and how the budget will affect emissions. This makes it more difficult both to recognise and to eliminate harmful policies and measures and to assess the adequacy of climate protection measures.

The role of the Ministry of Finance is to ensure that the Government's decision on spending limits and budget proposal include estimates of the direct and indirect impacts of the proposal on the climate, for use by Parliament. One way to improve the informativeness of the budget book would be to supplement it with a concise climate budget that would list the relevant budget items and their climate impacts. The climate perspective should also be strengthened in the performance targets defined in the budget.

Implementation of the Foresight Report must be followed regularly. The adequacy of measures taken to reach the targets must be assessed and, whenever necessary, decisions on supplementary solutions must be made. The latest research findings should be used in the assessment. Other relevant procedures, such as monitoring the Climate and Energy Strategy, will also be used to the extent possible. An initial report on implementation will be drawn up during the current Government term. A more extensive assessment will be prepared in 2013 so that the next Government can make the necessary political decisions in mid-term.

Box 10.1 Certainty and long-term orientation through a climate Act?

An Act setting binding national medium-term and long-term emission targets was passed in the UK in 2008. According to the Act and the associated carbon budgets, emissions in the UK need to be cut by 34 per cent from the 1990 level by 2020, and by at least 80 per cent by the year 2050. If the national targets are stricter than international requirements, the extra emission units cannot be relinquished for use by other countries.

The long-term targets have been divided into binding carbon budgets that set the maximum amounts of emissions for five years at a time. Three successive budget periods must be determined at any single time. Carbon units can be deposited and borrowed between budget periods.

A committee consisting of independent experts guides the Government in setting targets and carbon budgets and in planning actions. The committee also reports to Parliament annually on adherence to the budget. The minister is responsible for meeting the targets. However, the Act does not contain any actual sanctions for not meeting the obligations – in the same way as there is no actual penalty for exceeding a fiscal budget.

In public debate, many arguments have been presented in support of a climate act in accordance with the British model:

1. The Act is a strong indication of political will and a signal to other countries of the Government's preparedness to be committed to low-carbon paths.
2. It can be assumed that the Act will hold better than strategies across Government terms; this increases investment security important for business and industry.
3. The Act has set binding medium-term and long-term targets and has presented five-year carbon budgets leading from the present situation towards these targets.
4. The Act includes mechanisms for evaluating the targets against developments in climate science and for independent monitoring of the Government's actions.

In the UK, the Climate Change Act gives the Government very wide powers to decide on the means to reach the emission targets. Extensive delegation of legislative powers is in disagreement with the Finnish judicial system, where measures affecting individuals' rights and obligations must be stipulated in laws approved by Parliament. However, there are no legal obstacles to applying the Climate Change Act to the Finnish circumstances.

National climate strategies and the EU climate and energy package largely contain the same elements as the Climate Change Act. These include a medium-term emission target and an indicative emission path towards that target. There is reason to compare the strengths and weaknesses of the Climate Change Act against the existing means and to investigate its suitability to the Finnish conditions, especially outside the emissions trading sector.

Information to support decision-making

Well-advised decision making requires up-to-date and research-based information. Sufficient competence and resources must be available for ministries so that they can assess the climate impacts of decisions and integrate the climate perspective in all legislative drafting. Assessments of climate impacts must be included in operating and finance plans and in strategies. The climate dimension should also be strengthened in the environmental impact assessment of plans and programmes.

Ministries must together draw up a report on how climate impacts are assessed when proposals for regulations are prepared.

Organisations can redirect their human resources by appointing climate specialists and by providing training on climate issues for the personnel. Awareness-raising, changes in job descriptions, staff rotation and networking may also support mainstreaming.

Rational decision-making depends on information produced in various scientific disciplines. It is sensible to identify research needs in dialogue between scientists and decision-makers. It is also important to consider climate issues in the preparation, administration and assessment of research programmes.

Research on climate issues in various sectors has increased in Finland. However, much more information is still needed. For example, abrupt and extreme climate changes, emission differences between population groups, energy efficiency potentials, and the cost-effectiveness of climate policy measures are still inadequately known. Effective climate action requires sufficient resources for research that supports decision-making. Networking among scientific disciplines must also be increased.

Finnish universities conduct outstanding academic research, and information pertaining to climate-related information is also produced by institutes operating in various sectors, such as the Finnish Meteorological Institute, the Finnish Environment Institute, the Government Institute for Economic Research, VTT Technical Research Centre, MTT Agrifood Research Finland, the Finnish Forest Research Institute, and the Finnish Institute of International Affairs. Research has strong international links, and information produced abroad can also be utilised here.

Nevertheless, in a quickly changing situation, the challenge is often to produce multidisciplinary policy-relevant information and expert services. In particular, socioeconomic climate research is needed along with information obtained in the fields of natural sciences and technology. Unlike many other countries, Finland has no think tanks that would feed public debate.

Finland’s strengths include sectoral research and its close links with research conducted at universities. Through the Advisory Board for Sectoral Research, research in the climate sector could be compiled into a large and standing programme that has a clear link to decision-making. Research resources should also focus on the needs of climate protection more than at present.

Alternatively, climate know-how in various sectors could be concentrated in a multi-disciplinary and cross-disciplinary climate institute operating in conjunction with an existing university or research institute. This climate institute could also operate within a network and virtually, compiling know-how from existing research institutes.

Often the challenge is not only to produce information useful for decision-making but also to pass on this information to decision-makers at the right time and in the right format. Many countries have appointed 'science interpreters' to improve the flow of information between science and politics. For instance in the UK, the Government is supported by Chief Scientific Adviser, while in Germany the Federal Chancellor has been advised by Chief Government Advisor on Climate. In addition, the German Federal Government has received advice on global climate change issues from the German Advisory Council on Global Change (WBGU), consisting of independent experts.

People in all age classes and population groups must be given enough information about climate change and how to mitigate it. To some extent, the climate is already included in the curriculums of comprehensive schools and upper secondary schools through environmental education and subject studies. When the grounds for curriculums are revised, links between climate issues and teaching must be strengthened. The same must also be done in vocational education, in a manner suited to each vocational field.

Polytechnics and universities must integrate the climate in their research and teaching more explicitly. Universities play an important role in teacher training. The climate must be included in the basic training of all teachers, and the qualifications of current teachers must be improved through supplementary training.

In other sectors, too, the importance of supplementary training is accentuated in the rapidly changing society. People working in occupations of essential importance to low-carbon society, such as architects, housing managers, and household appliance retailers, must receive training that supports climate protection.

The regions and areas play a key role

Municipalities and the regions play a crucial role both in climate change mitigation and in adaptation to it. Municipalities and inter-municipal bodies take decisions on issues such as regional and urban planning, public waste management, basic education, energy consumption in buildings owned by municipalities, and public catering. Often they also play a role in energy production, local traffic and other similar issues.

Kuopio is a good local example of how climate policy can be mainstreamed. The City of Kuopio has resolved that the decisions of all bodies and corporations must be accompanied by the presenting official's view of whether the decision supports the goals of the city's climate policy programme.

Despite their important role, only a minority of Finnish municipalities have drawn up local climate strategies. Roughly one in seven Finnish municipalities (51 out of 348) take part in the climate protection campaign of the Association of Finnish Local and Regional Authorities. In comparison, nearly all Swedish municipalities that answered a questionnaire conducted by the environmental authorities have either an emission reduction target or plans to set such a target.

Climate protection can be an opportunity for municipalities. Introducing more efficient energy use and infrastructure saves money. Development of public transport and pedestrian and bicycle traffic improves people's health and makes for a more attractive living environment. Sustainable technology and services can create new jobs and tax revenues. One possible benefit, which is also the hardest to measure, is the commitment of people to their own municipality because they feel it acts responsibly and sustainably.

Climate policy objectives can hardly be realised unless they are taken to the level of local and regional government. The Government's Long-term Climate and Energy Strategy requires that urban areas and regions prepare their own climate programmes. It is justified to expand the scope of this requirement gradually to all municipalities.

Besides concrete and measurable targets for reducing emissions, improving energy efficiency and increasing the use of renewable energy, local programmes must include measures to reach these targets. Targets and means for reducing emissions from traffic must also be included. In addition, adaptation to climate change should be examined simultaneously.

A municipality can decide to prepare a climate programme on its own, but often it is sensible to draw up a joint programme for a sub-regional unit or a joint municipal authority. The first programmes must be completed by the end of 2012; thereafter they must be updated once every five years.

Municipalities have different prerequisites for local climate action. Especially many small and poor municipalities may find it difficult to reallocate the necessary financial resources and competence. Municipalities' own capacities and intermunicipal cooperation should be reinforced, and municipalities must be able to receive expert help from the national level. Municipalities can also build partnerships with enterprises, organisations and residents in their own areas. In this way, they can expand the coverage of climate action, utilise the competence of other parties, and reach more people.

In some countries, the government supports local climate action through direct funding, loans or guarantees. For instance, the Austrian climate and energy fund has a four-year budget of half a billion euros: some of this money is used to support municipalities.

In Finland, too, it would be justified for the government to support local climate action with seed funding. This can be implemented either by establishing a budget item for this purpose or by setting up a separate climate fund, from which municipalities and the regions can apply for support or low-interest loans for local climate projects. Financing could also be collected from other sources.

Box 10.2 Examples of active municipalities

Many municipalities in various countries have worked actively to reduce their own greenhouse gas emissions. One of the best-known cases is Växjö, a town of 80,000 residents in Sweden. During the past 12 years, the town has been able to cut its per capita emissions by one quarter and to raise the share of renewable energy to 50 per cent.

However, Växjö does not plan to stop here. The town's goal is to halve its per capita emissions by 2010 and to cut them by 70 per cent by the year 2025. By 2015, the aim is to increase cycling and the use of public transport by one fifth from the level of the early 2000s. The long-term objective is to get rid of fossil fuels altogether.

Within ten years, the city of Freiburg, Germany, succeeded in increasing the share of cycling by half and in reducing the share of driving by one quarter. At the same time, contrary to the general trend, car density in the city fell.

The island of Samsø in Denmark has been carbon neutral since 2003. All electricity is obtained from wind power, and 70 per cent of heat is produced using biomass and solar collectors. The remaining emissions are offset by selling wind power to other locations in Denmark.

In Finland, the Finnish Environment Institute has launched the project Carbon-neutral Municipalities. In the project, five municipalities act as living laboratories of local climate protection and strive to reduce emissions well ahead of schedule. The project is based on a partnership of all local actors. The preliminary results are encouraging: For example in Uusikaupunki, it may be possible to cut emissions by as much as 30 per cent within five years.

The Government's policies

- Climate policy expertise to support State leadership is ensured and strengthened.
- The climate perspective is strengthened in the preparation and presentation of State budgets.

- Implementation of the foresight report is monitored and assessed; whenever necessary, decisions on supplementary solutions are made to attain objectives.
- The advantages and disadvantages of a Climate Change Act similar to that of the UK are investigated, and the applicability of such an Act to Finland is assessed.
- Research to support climate policy is increased. Ministries are ensured sufficient resources so that the climate perspective can be integrated in decision-making in each administrative sector.
- An operating model is created for coordinating climate communications within public administration.
- The climate perspective is reinforced in education at all levels.
- Municipalities are required to draw up a regional or municipal climate programme that includes targets and measures for reducing emissions.
- Local and regional climate action is supported through seed funding, low-interest loans, or some other similar arrangement.

Summary of policies

Vision: Low-carbon Finland in 2050

- Measures are taken in order to limit global warming to two degrees Celsius at most.
- Finland's emissions are cut by at least 80 per cent from the 1990 level by 2050 as part of a wider international effort.
- The shift to a low-carbon society is carried out in a way which promotes well-being.
- The targets are revised whenever necessary as scientific information becomes more accurate and international cooperation progresses.

Targets towards a low-carbon society

The targets set are:
- in the long term, to shift to a virtually zero-emission energy system and passenger road traffic
- to cut the energy intensity of the economy by least 50 per cent by the year 2050 through radical improvement of energy efficiency
- to improve the efficiency of energy use in buildings so that consumption in 2030 will be at least 30 per cent, in 2040 at least 45 per cent, and in 2050 at least 60 per cent lower than now
- to gradually phase out the use of fossil fuels and peat in energy production as power plants are decommissioned, unless carbon-capture technology is installed
- to continue raising the share of renewable energy so that it will reach at least 60 per cent of all end use of energy in 2050
- to cut emissions from passenger cars to at most 80–90 g CO_2/km in 2030, 50–60 g in 2040 and 20–30 g in 2050
- to gradually abandon the present-form landfilling of waste.

The most important measures

Use and production of energy
- Energy conservation and improving energy efficiency are given priority in emission reduction in all sectors.
- The energy standards for new buildings will be revised after 2012 to facilitate a gradual transition to passive houses.
- When existing buildings are renovated, their energy efficiency needs to be improved substantially.

- Feed-in tariffs and other economic steering measures are implemented so that they are comprehensive enough in view of the goals to increase renewable energy.
- Small-scale production of energy by consumers is promoted through administrative and financial means.
- Carbon capture and storage (CCS) is developed and tested.

Transport, urban structure and consumption

- In transport, the emphasis of economic steering will shift to the use of motor vehicles.
- Allowance is made for the investments required to attain long-term emission targets in public transport.
- Planning guidance is enhanced in urban areas in order to improve cohesion of the urban structure.
- Information concerning the climate impacts of choices in everyday life is made easily available to people.
- Recycling and energy use of waste, and prevention of waste production, are substantially increased.

Guidance and structures

- Partnerships among State administration, local administration, business life, organisations, and citizens are strengthened in order to reach climate objectives.
- Policies and measures leading to the production of emissions are assessed and, whenever necessary, changed.
- Financing for the development and deployment of climate-friendly and sustainable technology and services is increased.
- Taxes discouraging emissions are developed and raised outside the emissions trading sector.
- The climate perspective is reinforced when State budgets are prepared and presented.
- Municipalities are required to draw up a regional or municipal climate programme that includes targets and measures for reducing emissions.
- Local and regional climate action is supported by means of seed funding, low-interest loans, or some other similar arrangement.
- The climate perspective is reinforced in education at all levels.
- A multidisciplinary and independent group of experts is appointed to monitor research in the climate sector and to advise the Government.

International cooperation

- Determined action is taken to achieve comprehensive and efficient agreements in climate negotiations.

- Effort is made to support and strengthen the European Union’s leading role in international climate protection.
- Active work is done to strengthen the climate perspective in international cooperation in all forums.
- Effort is made to introduce comprehensive and global emissions trading.
- Prompt action is taken to liberalise trade that promotes climate protection.
- The transfer of climate-friendly technology to developing countries is accelerated markedly.
- Carbon-neutral development cooperation is introduced as soon as possible.
- The concept that development funding should be sustainable in terms of the climate is promoted in international development banks and other forums.
- The target is set to stop global deforestation and to achieve an upturn in the total forest area by 2020 at the latest.
- Development cooperation balancing the population trend is emphasised and increased also for climate reasons.
- Provision is made to increase public funding for climate action in developing countries in line with Finland’s own fair share.

Areas requiring further study

- More research is conducted on extreme and abrupt climate changes and on feedback mechanisms in the climate system.
- The means of reducing atmospheric concentrations of greenhouse gases and cooling the climate sustainably and safely are assessed.
- Work is continued to develop scenarios for a low-carbon Finland using a participatory approach, and potential paths towards a carbon-neutral Finland are studied.
- Climate policy is assessed from the perspective of sustainable development.
- Assessment of the economic and employment impacts of climate policy is developed and diversified.
- The indicators of sustainable well-being are developed, tested and applied in order to supplement GDP data.
- More research is conducted on how urban structure affects emissions.
- More research and awareness-raising are undertaken concerning the climate impacts of food.
- The indirect impacts of climate change that are transmitted to Finland from other parts of the world are studied.
- A comprehensive estimate of the costs of adaptation is drawn up.
- More research is conducted on the cost-effectiveness of climate policy.
- It is investigated whether road user charges based on satellite positioning can be adopted in the future. These charges would be scaled depending on the time, place, and the emission level of the vehicle.

- The role of public procurement in the commercialisation of sustainable technology is investigated.
- The advantages and disadvantages of a Climate Change Act similar to the one passed in the UK are studied, and the applicability of such an Act to Finnish conditions is assessed.

Appendix 1: Description and assessment of scenarios of the foresight report

Four possible storylines of how to achieve a low-carbon Finland were drawn up for this foresight report. They illustrate some clearly distinguishable ways of reducing emissions by at least 80 per cent. The objective is to present the alternative development trends as equal; none of them is put forward for implementation as such.

In the scenario Efficiency Revolution (A), the efficiency of energy use is radically improved, and final energy consumption in Finland is cut by half. All energy is produced using renewable sources. The regional structure is developing towards 8–12 strong, urban regional centres.

Services are quickly gaining a dominant role in the economic structure while the share of industry is decreasing. The forest industry that now consumes a lot of purchased energy has been replaced by new types of industry based on a high degree of processing and know-how. New 'Nokias' have emerged in clean technology.

In the scenario Sustainable Daily Mile (B), the regional structure has developed towards service centres, located throughout Finland, around which building is efficient. Daily services are obtained in the vicinity, and traffic volumes have decreased markedly. There is less focus on consumption, and services are replacing products.

New types of industrial production make use of biorefineries, information and communications technology, and recycled raw materials. Ecological design and construction are new export products. The use of nuclear power has increased.

The scenario Be Self-sufficient (C) aims at self-sufficiency and locality. Single-family houses produce most of their own energy. About twenty strong regional centres have attracted new housing. Cars run on zero-emission electricity and on domestic biofuels.

The forest industry has been converted to bioindustry, and Finland has a strong domestic food industry. There is demand for new construction, renovation and wood construction supporting energy self-sufficiency. Renewable sources account for a large share of energy consumption. Vegetarian and local foods are increasingly popular.

In the scenario Technology is the Key (D), concentration of the population in Southern Finland has continued strong. The urban structure around major cities is dispersed, and the population in rural areas has decreased considerably. The increased transport demand is satisfied by electric cars and high-speed trains.

Energy consumption is at the present level, and industry's share is large. Much more nuclear power has been built. Because of the great energy demand, fossil fuels are still used with carbon capture and storage. An energy-efficient knowledge-intensive industry is located in the south of Finland. Natural resources are utilised efficiently in energy-intensive industries outside densely-populated areas of Southern Finland.

Table 1 Main features of the scenarios

	A: Efficiency Revolution	B: Sustainable Daily Mile	C: Be Self-sufficient	D: Technology is the Key
Leading idea	Eco-efficiency	Local services	Self-sufficiency	Industrial Finland
Average annual economic growth	1.7%	1.8%	1.2%	1.8%
Economic structure	The share of services has increased clearly	The share of services has increased	The share of services has increased slightly	Similar as compared to the present
Urban structure	Cohesive	Highly cohesive	Dispersed	Dispersed in urban areas
Passenger transport performance	Decreased	Decreased clearly	At the present level	Increased
Final energy consumption	Halved	Decreased by 1/4	Decreased by 1/3	At the present level
Share of renewable energy	1/1	2/3	4/5	3/5
Use of nuclear power	Ended	Increased	Decreased	Increased clearly

Finnish business and industry in 2050

Underlying the low-carbon paths, there are general assumptions about economic and business trends. The assumptions selected do not take a position for or against the development of certain businesses; instead, based on assessments made by experts, they represent potential and sufficiently different development trends. In any case, assumptions about future economic structures involve major uncertainties.

The volume of services increases in all of the scenarios, and in some, even substantially. The share of services in the GDP ranges from two thirds in scenario D to four fifths in scenario A. Growth is expected, for instance, in the sectors of well-being services and tourism. In addition, the creative economy and business services associated with low-carbon society provide employment.

In all of the scenarios, industry is modernised and becomes more efficient than at present. In scenario A, industry's share of the GDP is reduced by half, owing to structural change and the increase in services. In scenario D, the share and structure of industry remain more or less the same as now, and owing to economic growth, output will increase markedly. In scenarios B and C, the share of industry falls by one third.

In some scenarios, the share of industrial production in its present form declines clearly or peters out almost completely. Current products will be replaced by new ones with a high degree of processing or even by totally new sectors. For instance, innovations in nano, bio and information technologies may act as catalysts for new export industry. The importance of recycled raw materials and renewable natural resources will increase. Climate technology and ecological construction may be important sectors.

The share of primary production varies. In scenario C seeking self-sufficiency, food is produced domestically to the extent possible, whereas in scenario D agriculture has shrunk considerably. Forests are an important resource for industry and energy production in all of the scenarios.

The scenarios sought to map out Finland's roles in the global economy of the 2050s. The share of services in the Finnish economy may rise rapidly if the global division of duties proceeds in a direction enabling this. On the other hand, industry's position may remain strong if production can be revamped so that emissions are kept low. Know-how and skills play an important role in all of the scenarios.

Energy consumption by sector

The work on the scenarios shows that Finland can reduce emissions by at least 80 per cent in a variety of different ways. All low-carbon paths require energy conservation and significant improvements in energy efficiency in all sectors. In the scenarios, energy consumption either decreases clearly or remains roughly at the present level.

Electricity consumption decreases in all other scenarios except D, where it increases because of industry. However, electrification of society continues: electricity will cover an increasing share of energy in all of the scenarios.

Table 2 Final energy consumption in the scenarios (TWh)

	2007	A	B	C	D
Industry	108	54	111	81	150
Electricity used by services and households	30	26	20	26	36
Heating	62	27	30	31	37
Transport	50	15	21	25	21
Total	***250***	***122***	***183***	***163***	***245***

The figures have been rounded to the nearest full terawatt-hour. The data for heat pumps show their effective heating energy. The figures do not include direct use of fuels by industry (ca. 49 TWh in 2007).

Energy consumption decreases sharply in the heating of residential and service buildings. In construction practices of new building projects, there will be a gradual transition towards clearly improved energy efficiency, while the energy efficiency of old buildings is improved in conjunction with renovations.

Table 3 Heating of residential and service buildings (TWh)

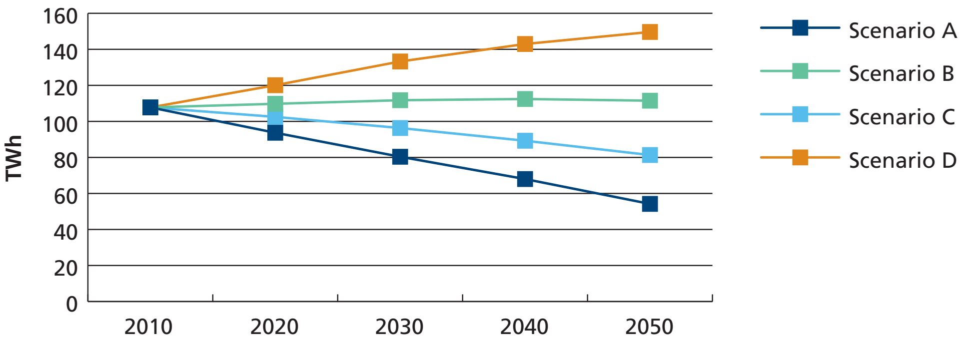
	2007	A	B	C	D
District heating	28	14	17	10	13
Electric heating	9	6	5	5	15
Heat pumps	2	3	3	5	4
Other	23	4	5	11	5
Total	***62***	***27***	***30***	***31***	***37***

The figures have been rounded to the nearest full terawatt-hour. The data for heat pumps show their effective heating energy.

In scenario A, buildings with poor energy efficiency are torn down. Living space per capita remains unchanged in B, increases slightly in A and C, and increases clearly in D. In scenarios A and B, it is assumed that room temperatures are reduced by two degrees Celsius.

Industry's energy consumption depends on the volume, structure and efficiency of production. All of the scenarios assume that the specific efficiency of production will improve on average by one fifth.

Figure 1 Trend of energy consumption in industry



The scenarios differ considerably in terms of energy consumption. In scenario D, industry consumes nearly three times as much electricity and heat as in A.

Table 4 Industry's energy consumption (TWh)

	2007	A	B	C	D
Electricity	48	26	50	38	69
Heat	60	28	61	44	80
Total	***108***	***54***	***111***	***81***	***150***

The figures have been rounded to the nearest full terawatt-hour.

The efficiency of electricity use by services and households will improve substantially. In the scenarios of the most rapid development, the energy efficiency of household appliances will rise by 30 per cent by 2030 and by 60 per cent by 2050. In some scenarios, the increase in the number of appliances will eat some of the savings achieved through improved efficiency, but in B the number of appliances, and thereby also consumption, will be smaller.

Table 5 Electricity consumption by services and households (TWh)

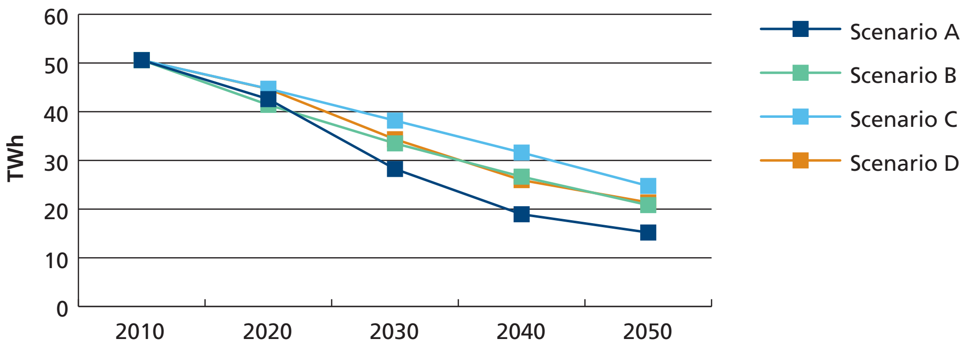
	2007	A	B	C	D
Services	15	16	11	15	20
Households	11	8	6	9	11
Other	3	2	2	2	5

The figures have been rounded to the nearest full terawatt-hour. They do not include electric heating.

In all of the scenarios, the volume of services increases clearly; this raises their electricity consumption. On the other hand, improved energy efficiency cuts the need. In scenario A, lighting efficiency is estimated to improve by 60 per cent and that of other electricity use in the service sector by 30 per cent by 2050.

The energy consumption of transport varies depending on the transport demand, modal split and efficiency of vehicles. Passenger transport performance will decrease by more than one fifth in B and by one tenth in A, while in C the performance remains at the current level and in D it rises by one third. In scenario B, it is assumed that the utilisation rate of cars will increase.

Figure 2 Trend in the energy consumption of transport



In all of the scenarios, driving will cover a smaller share of passenger traffic than at present. In scenario B, with its short distances, the share of bicycle and pedestrian traffic even triples. In scenario A, the most urban scenario, the share of public transport increases by more than 50 per cent.

Table 6 Percentage of passenger transport performance

	2007	A	B	C	D
Cars	80	65	65	76	77
Public transport	15	25	20	19	18
Bicycle and pedestrian traffic	5	10	15	5	5

It has been assumed that the energy efficiency of cars with internal combustion engines will double by 2050. Energy consumption decreases the most in the scenarios where the transition to electricity-powered transport is rapid, because an electric motor is considerably more efficient than an internal combustion engine. In scenarios B and C, electric cars will only account for one fifth of all cars, but in A their share rises to 90 per cent, and in D all cars are electric.

Industry's transports will remain more or less at the present level in A, where the share of services rises steeply, but will increase by two fifths in B and C and double in D. In all of the scenarios, transports for services will increase in step with the volume of the sector. Heavy road traffic runs mostly on fuels, but in scenario D the share of electricity will rise to 30 per cent and in A to 50 per cent.

Table 7 Supply of district heating and heating for industry (TWh)

	2007	A	B	C	D
District heating (CHP)	25.4	11.1	1.4	8.0	4.6
District heating (separate production)	7.8	2.8	3.8	2.5	2.9
Industry (CHP)	49.4	25.4	9.2	31.0	72.2
Industry (separate production)	12.3	2.8	52.0	12.7	2.8
Nuclear district heating	0	0	10.9	0	7.1
Total	***94.9***	***42.1***	***77.3***	***54.2***	***89.6***

Transmission losses in the district heating network have been taken into account. The figures do not include production for low-energy heating networks.

Energy generation in the scenarios

In practice, low-carbon paths require the transition to a virtually zero-emission energy system. This requires a marked increase in the utilisation of zero-emission energy sources and a gradual phasing out of fossil fuels and peat without carbon capture and storage.

For electricity production, nuclear power remains the most important single production mode in scenarios B and D, which are based on the construction of additional nuclear power plants. In scenarios A and C, the most important source is wind power. Separate production of condensing power will fall in all of the scenarios. Electricity generation through combined heat and power production (CHP) will increase in scenario D, but will decrease in the other scenarios.

Table 8 Supply of electricity in the scenarios (TWh)

	2007	A	B	C	D
Nuclear power	22.5	0	41.6	13.1	64.6
Hydropower	14.0	14.6	15.2	17.5	15.2
Wind power	0.2	22.9	18.6	20.3	22.1
CHP with renewable sources	9.2	17.4	4.0	16.6	27.2
CHP with other sources	17.4	0	0	1.3	7.3
Condensing power	14.5	8.4	0	5.0	8.5
Other	0	0.8	0	0.3	0
Imports (+) or exports (–)	12.6	4.8	0	0	–6.1
Total	***90.3***	***68.9***	***79.3***	***73.8***	***144.7***

The supply of electricity comprises domestic consumption, transmission losses, and exports abroad, if any.

In all of the scenarios, production of heat decreases along with consumption. However, there is major variation in the production structure. In scenarios A and C, most heat for district heating and industry is produced by CHP plants, whereas in scenario B, in particular, the share of separate production will become very large. In scenarios B and D, district heat is also produced by nuclear power.

Energy self-sufficiency improves considerably in all of the scenarios. In scenario A, all of the energy produced in Finland is based on indigenous energy sources. Moreover, imports of green electricity cover four per cent of energy consumption in A.

Table 9 Indigenous energy sources and energy based on imported fuels (per cent of consumption)

	2007	A	B	C	D
Indigenous energy sources	35	96	70	91	66
Energy production based on imported fuels	61	0	30	9	34
Electricity imports (+) or exports (–)	4	4	0	0	–3

If nuclear power, based on the use of imported fuels, is included in domestic energy production, the highest rate of self-sufficiency is reached in scenario B, where all of the energy is produced in Finland.

Energy production by source

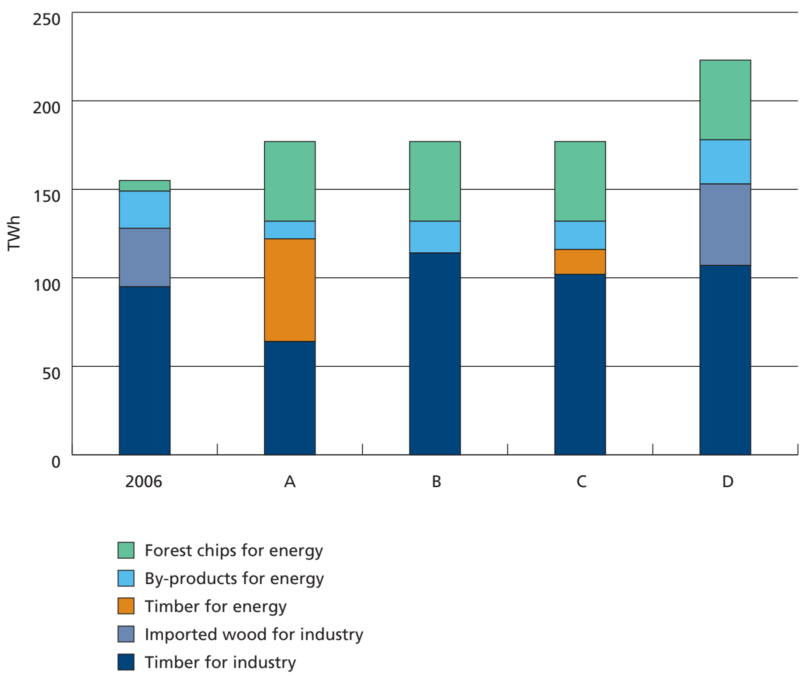
In all of the scenarios, renewable energy production rises clearly above the other sources. In A, all of the energy is generated with renewables but even in D, which relies on nuclear power and fossil fuels more than any other scenario, the share of renewables will rise to 57 per cent of consumption. The amount of renewable energy produced is the greatest in D since it is needed to cover the large total consumption of energy.

Table 10 Sources of renewable energy (TWh)

	2007	A	B	C	D
Forest energy, of which	83.3	76.8	82.3	77.3	113.0
- waste liquors	*43.3*	*10.8*	*26.9*	*24.1*	*51.6*
- by-products	*20.7*	*10.3*	*18.3*	*16.4*	*24.6*
- energy wood	*19.3*	*55.8*	*37.0*	*36.9*	*36.8*
Arable energy	0.3	5.1	5.0	4.0	5.0
Biogas	0.4	0.6	0.6	1.2	0.2
Waste-derived fuels	1.1	1.1	0.6	0.8	2.3
Hydropower	14.0	14.6	15.2	17.5	15.2
Wind power	0.2	22.9	18.6	20.3	22.1
Other (solar, waves)	0	0.8	0	0.3	0
Total	***99.3***	***121.9***	***122.3***	***121.4***	***157.8***

In all of the scenarios, forest energy remains clearly the most important source of renewable energy. It accounts for about two thirds of renewable energy. In scenario A, the main source is wood not needed in the forest industry, whereas industrial sideflows remain the most important sources of bioenergy in the other scenarios. Biogas, arable energy and waste-derived fuels account for about five per cent of renewable energy altogether.

Figure 3 Wood use in 2006 and the potential for constructional timber and energy wood in 2050



Wind power becomes the second most important source, after bioenergy. The amount of electricity generated by wind power will increase to 19–23 terawatt-hours by 2050, which is many times over the target of 6 TWh determined by the Climate and Energy Strategy for 2020. The share of wind will rise to 15–33 per cent of electricity consumption.

Hydropower will remain the next most important source of renewable energy. Owing to increased precipitation resulting from climate change, and the modernisation of power plants, the output of hydropower increases in all of the scenarios. In scenarios B and D, small-scale hydropower and new power plants will be constructed in rivers that are not protected. In scenario C it is additionally assumed that sites of economic importance will be utilised in protected water systems (e.g. the Ounasjoki River, the reservoirs of Vuotos and Kollaja). Hydropower covers 11–24 per cent of electricity consumption.

Heat pumps will be used much more in the heating of buildings in the short and medium terms. In 2020, some 400,000–500,000 air-source heat pumps and about 200,000 ground-source heat pumps will be used to provide heat for individual buildings. By 2050, the number of pumps starts to decline because other heating techniques will be selected in new buildings.

In addition, the scenarios include small quantities of solar power. The maximum number of solar collectors is 90,000 in scenario C. In scenario A, wave power plants are also taken into use.

The importance of nuclear power varies considerably between the scenarios. In scenario D, the production of nuclear power more than triples, and in scenario B more than doubles from the present. In scenario C, on the other hand, the production of nuclear power will fall by two fifths, while in scenario A nuclear power will be phased out completely.

At its most in scenario B, nuclear power will account for over 50 per cent of electricity consumption and 30 per cent of all final energy consumption. In some scenarios, the production of district heating increases the importance of nuclear power. In scenario D, just under half of district heating is produced with nuclear power, whereas in scenario B this figure is over two thirds.

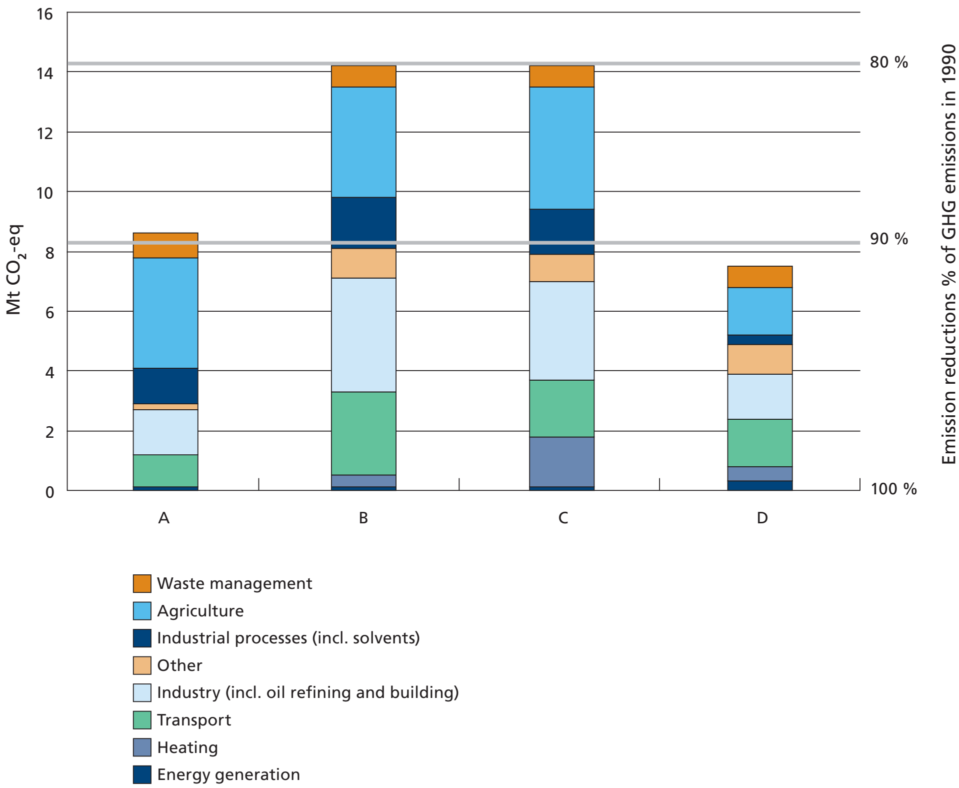
The present forms of fossil fuel use for energy production will be phased out in all of the scenarios. In scenario D, coal and natural gas continue to cover seven per cent of energy production, but with carbon capture and storage, emissions can virtually be eliminated. In the other scenarios, fossil fuels are not used at all for energy production.

In scenario C, peat covers a good ten per cent of the energy need, while in scenario D this figure is just under ten per cent. In centralised energy production, the use of peat involves no emissions because of carbon capture and storage.

Trend in emissions

In all of the scenarios, Finland's emissions can be reduced by 80 per cent or more from the 1990 level by the year 2050. In scenario A, the reduction is nearly 90 per cent and in scenario D over 90 per cent.

Figure 4 Greenhouse gas emissions in the various scenarios



The most radical fall in emissions will take place in energy generation, from over 27 million tonnes at present to almost zero. The most important means for achieving this are improvements in energy efficiency, the replacement of fossil fuels and peat with renewable energy sources and nuclear power and the use of carbon capture and storage. The only energy-related emissions in 2050 will come from waste incineration, altogether 0.1–0.3 million tonnes. One can therefore speak of a virtually zero-emission energy system.

A radical reduction of emissions will also take place in transport. Emissions will decrease from the present 14 million tonnes to 1.1–2.8 million tonnes, or to one fifth or even less than one tenth of the current level. In scenario D, transport will become the greatest source of emissions, alongside agriculture.

Emissions from passenger traffic are cut because of the reduced transport demand, increased popularity of public transport and bicycle and pedestrian traffic, improved energy efficiency of cars, biofuels, and transition to electric cars. Increased rail transports, more efficient vehicles, and alternative fuels reduce emissions from goods transports.

Table 11 Emissions from cars (g CO_2/km)

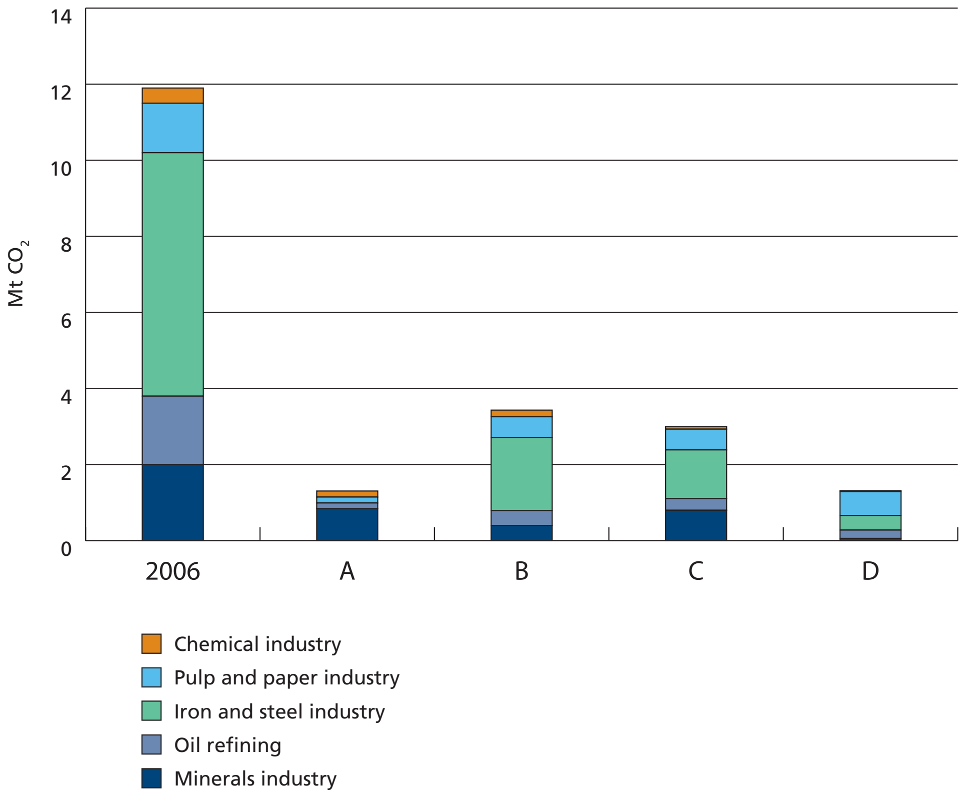
	2010	2020	2030	2040	2050
Scenario A	163	120	40	9	3
Scenario B	163	124	76	52	38
Scenario C	163	121	66	32	16
Scenario D	163	112	42	8	0

The figures comprise direct emissions from the use of fossil fuels in passenger cars. Emissions from electricity and biofuels used in cars are not included in these figures; they are included in the production balances of these energy sources.

Emissions from heating will also decrease substantially in all of the scenarios: from the current 4.9 million tonnes to 0.4–1.7 million tones – even to zero in scenario A. The main reasons for this decrease are the improved energy efficiency of buildings and the shift to renewable energy sources. In scenarios C and D, the use of peat pellets causes emissions.

Emissions from the use of fuels in industry (including construction and oil refining) can be cut significantly in all of the scenarios, but the remaining emissions still amount to 1.5–3.8 million tonnes. In scenario B, this sector becomes the most significant source of emissions.

Figure 5 Change in industrial emissions included in emissions trading



Emissions from industrial processes (including the use of solvents) will decrease from the present 6.8 million tonnes to one quarter or even to one twentieth part. Emissions are reduced, for instance, by improving efficiency, by using new techniques and by shifting to carbon capture and storage.

The sector where achieving considerable emission reductions is the most difficult is agriculture. In three scenarios, agriculture will be the most important emission source in 2050. In scenarios A, B and C, emissions are cut from the present 5.6 million tonnes to just 3.7–4.6 million tonnes. Emission reductions are achieved through measures such as anaerobic digestion of manure, reduced use of fertilisers, replacement of animal products with plant-based products, and restrictions on cultivation in peat fields.

In scenario D, emissions from agriculture are reduced to 1.6 million tonnes, but this is because some of the food produced in Finland is replaced by imports. In the scenario, the cultivated arable area has fallen by 60 present and the amount of dairy cattle by 70 per cent from the present level.

Thanks to improved energy efficiency, biofuels, and electrification of equipment, emissions from machinery are reduced in all of the scenarios from the present 2.6 million tonnes to less than one million tonnes.

In waste management, emissions continue to be reduced. The current 2.4 million tonnes can be cut by about two thirds. The most important measures are the minimisation of waste volumes, recycling, anaerobic digestion for biogas, utilisation of waste-derived fuels as energy, and improvement of the efficiency of waste water treatment.

Other emissions mostly stem from the evaporation of fuels. The importance of this category is slight, with the exception of scenario D, where its share will rise to just under ten per cent of all emissions.

Table 12 Sources of emissions today and in 2050 (share of Finland's emissions, %)

	2007	A	B	C	D
Energy production	35	1	1	1	4
Fuels for industry (incl. oil refining and construction)	18	18	27	23	20
Transport	18	13	20	13	21
Industrial processes (incl. solvents)	9	14	12	11	4
Agriculture	7	44	26	29	21
Heating	6	0	3	12	7
Machinery	-	2	6	4	5
Waste management	3	9	5	5	9
Other	4	0	1	2	8

Review of paths

The results of the scenario work are presented as descriptions of a low-carbon Finland in 2050 when compared against the initial situation in 2007. The timing of changes required was also considered in the calculations so that targets can be reached without sudden and radical turns.

In scenario D, final energy consumption will remain more or less at the current level throughout the assessment period. In the other scenarios, consumption will fall below the target level determined in the Climate and Energy Strategy for 2020. In scenario A, the difference is over ten per cent. In scenarios B and C, consumption in 2030 will be more than 15 per cent below the initial level; in scenario A, as much as 30 per cent below. Consumption will continue to decrease after that as well.

Rapid action is needed especially in the heating of residential and service buildings. In the scenarios, consumption will decrease from the present level so that in 2020 it will be about 15–30 per cent, in 2030 about 25–40 per cent and in 2040 as much as 30–50 per cent lower than at present. To reach these paths, stricter energy standards need to be set for new buildings and marked improvements must be attained in the energy efficiency of the existing building stock.

In scenario D, electricity consumption will increase considerably from the present level. In the other scenarios, it starts to drop, and in 2020 it will be clearly below the target level in the Climate and Energy Strategy; in scenario A, the difference is almost twenty per cent. In 2050, consumption in scenario B would roughly correspond to the long-term vision presented in the strategy, while in scenarios A and C, consumption would be clearly lower than that.

In energy production, preparations for future emission targets must take place in good time, owing to the long life times of power plants. These targets will, even in the near future, restrict the construction of power plants fired by fossil fuels or peat without carbon capture and storage. On the other hand, the design and construction of new nuclear power plant units takes a long time, and building more than one unit at the same time would be challenging. Depending on the policy selected, decisions must therefore be made in good time.

Solutions for carbon capture and storage must be commercialised quickly so that they could be utilised as planned in scenarios C and D. In practice, the technology should be in widespread commercial use by 2020, and the commercialisation of a smaller plant size class should be successful in the 2030s.

Challenges and opportunities in energy use

The review of the scenarios shows that it is possible to cut Finland's emissions by 80 per cent or more by the year 2050. The necessary emission reductions seem to be possible by utilising technology that is already in use or under development. However, major changes are needed especially in energy production, transport, industry and agriculture.

The greatest challenge in the heating of buildings is to ensure sufficient improvement in the energy efficiency of existing buildings. The swift tearing down of existing buildings, assumed in scenario A, and the drop in room temperature in scenarios A and B also seem challenging.

A big question in the use of electricity is how to achieve a downturn in the electricity consumption of households if homes continue to become better equipped. The rapid growth of the services makes it more difficult to cut electricity consumption in this sector.

In industry, it may be hard to achieve the necessary emission reductions without structural changes. The radical renewal of industry, assumed in scenario A, may be very challenging both technically and financially. If the consequence of restructuring is that carbon-intensive production moves to other countries, the outcome is not a sufficient reduction in total emissions. In scenario D, the rapid growth of the existing industry requires major investments in emissions reduction.

On the other hand, the assumption that the efficiency of industry's energy use will improve by one fifth can be regarded as moderate when considering the time span and the global investments in energy-efficient solutions. In particular, the use of heat can be made much more efficient in many industrial sectors.

In transport, the most difficult aspect may be the marked reduction in the transport demand, since so far it has risen steeply. Achieving a considerable increase in the share of public transport also requires a dramatic turn in current trends. On the other hand, the scenario assumption that the energy-efficiency of cars will double seems rather cautious in relation to estimates concerning technological development.

The electrification of heavy traffic in transports may proceed more slowly if technology does not develop rapidly. It has been assumed that the transports required by services will follow the sector's volume. This may, in turn, underestimate the potential for improved efficiency as technology and practices develop.

Potential bottlenecks in energy production and emission reduction

In energy production, Finland's biomass reserves enable a major increase in the use of bioenergy. The scenarios utilise bioenergy not only in base load production but also at peak load plants and in reserve facilities. This increase requires active development of the harvesting chain and storage of biofuels in both forestry and agriculture.

In scenario A, some of the timber used by industry has been freed for energy use, and wood is also used as fuel in condensing power plants. This may not necessarily be an ideal solution for the national economy. In the other scenarios, domestic forest biomass is utilised to a full extent. Biofuels are imported in scenarios B and D; in the latter, biomass is also imported for industry's raw material.

Disturbances in the availability of domestic biomass would impede the attainment of goals. Imported wood may not be readily available when the use of renewable energy is stepped up everywhere and competition over biomass becomes fiercer. The political acceptability of imported biomass may also wane.

The share of wind power rises sharply in all of the scenarios. Technically this is possible; however ensuring sufficient regulating power and the economics of operations become challenging. In the scenarios relying on additional nuclear power, it may be necessary to use nuclear power as regulating power, which weakens its profitability. Storage of wind power may also require more efficient and more economical solutions than those currently in use.

Utilisation of carbon capture and storage depends, in particular, on the development and price of technology. Commercialisation requires brisk technology cooperation on a global scale and possibly some support from society. Developing smaller scale applications of this technology is important for Finland. Because of carbon dioxide transports, it is easiest to take the technology into use at large energy and industrial facilities located along the coast. Problems in the adoption of this technology would mean a major obstacle to the attainment of emission reductions in scenarios C and D.

Use of nuclear power is stepped up significantly in scenarios B and D. These paths have challenges, such as how to make nuclear-powered district heating economically profitable, and issues relating to political acceptability. Scenario B is particularly vulnerable to risks associated with nuclear power, since more than half of the electricity in this scenario is produced with it. In scenario D, it is assumed that a fast-breeder reactor will be built towards the end of the assessment period; this is not yet commercial technology.

In the other sectors, the greatest efforts will be needed in agriculture. The introduction of grass cultivation on organic soils would involve major changes in the production structure. Important long-term emission reductions are hard to achieve without cuts in carbon-intensive production. Emission reductions will be particularly challenging if agricultural production increases markedly in Finland as the climate keeps warming and the demand for food rises globally.

Scenario D rests on a substantial reduction of agriculture in Finland; this would be a possible but politically questionable option. In practice, it would also mean that emissions from agriculture are transferred to other countries. The synthetic production of meat, assumed in the same scenario, is still in the initial phases of technical development.

Basic technology for manufacturing second-generation biofuels for transport is known, but its application in production plants of a commercial scale calls for technological development. Especially in scenarios relying heavily on biofuels, production needs substantial support so that adequate output can be achieved.

As such, significant reduction of industrial emissions seems possible. However, technology leaps are required. In the light of present-day knowledge, some technologies that reduce emissions may also be quite expensive without society's support.

Comparison of paths in terms of the economy

All of the scenarios reviewed would be better than the current trend in the sense that they reduce Finland's emissions to a sustainable level. The scenarios are also more desirable when measured by many other criteria. From some perspectives, however, the scenarios could also involve setbacks, and there are clear differences between the scenarios, depending on the criteria applied.

The premise selected for all of the scenarios was that the economy will continue to grow. Within the scope of this work, it was not possible to calculate precise economic impacts using proper model runs. Moreover, making assessments that extend over several decades is challenging. However, effort was made to outline economic impacts as part of the overall assessment of the scenarios and by using experts' assessments of individual sectors and technologies.

Table 13 Estimate of the economic impacts of the scenarios

Aspect/ scenario	A: Efficiency Revolution	B: Sustainable Daily Mile	C: Be Self-sufficient	D: Technology is the Key
Investments on market terms	Moderate	Significant	Moderate	Highly significant
Public investments	Significant	Significant	Moderate	Highly significant
Public support, input or steering measures	Highly significant	Highly significant	Moderate	Highly significant
Employment	Highly significant	Highly significant	Moderate	Significant
Imports and exports	Significant	Significant	Very slight	Highly significant
Energy costs	Slight	Significant	Moderate	Highly significant
Security of supply	Good	Good	Excellent	Moderate

The scale consists of five steps (very slight, slight, moderate, significant, and highly significant). For security of supply, the scale is: very poor, poor, moderate, good, excellent. The aspects and their estimates are not commensurate with each other.

In all of the scenarios, investments on market terms are needed for wind power, construction (the most in A), industry (the most in D), and new sectors (especially in A). In some scenarios, investments are also made in nuclear power (D, also B) and carbon capture and storage (C and D).

The need for public investments comprises the development of the regional and urban structure (A, B and D) and the need of transport (C, D) and housing (especially A). Regional income transfers are also likely to be needed (B and C).

Public support, input and steering measures focus, for instance, on the promotion of energy efficiency (A), new industrial sectors (in particular A and D), development of self-sufficiency (C), subsidies increasing the use of biomass (B, C and D), support for heat generated by nuclear power (B), and investments in carbon capture and storage (C and D).

For employment, the services sector plays the most important role in all of the scenarios (especially in A and B). Industry maintains a major role in scenario D. The number of jobs in agriculture varies from one scenario to the next (plummeting in D). Shortage of labour is a greater threat than unemployment, for instance, in biomass collection, renovation, and services.

Imports and exports depend, above all, on the role of the industrial sector (great in D, also in B). Exports may also serve as the engine in the sale of services (A).

Energy costs were estimated only by considering the volumes of energy use, without the impact of world market prices. Thus, costs are the highest in the scenarios where consumption is also the greatest.

It is also possible to try to give a rough estimate of the energy price. The price will rise in all of the scenarios, owing to stiffer international competition and the adoption of more expensive production techniques. The price of biomass will rise when demand increases and raw material must be obtained from more difficult locations. However, the total costs of energy do not necessarily rise in the scenarios in which consumption correspondingly remains low.

Security of supply was assessed particularly from the perspectives of agriculture (poor in D) and energy (good or better in all of the scenarios). Security of supply improves in all of the scenarios, but in C it is the best. In scenarios A and C, nearly all of the energy is produced domestically and is based chiefly on indigenous energy sources. If there are any problems in the availability of imported biomass, this may weaken the security of supply in some scenarios.

The scenarios have losers and winners. The radical restructuring of industry puts society to test in scenario A, the considerable downsizing of agriculture in scenario D. In terms of regional balance, the strongest scenarios are B, with its several strong centres, and C, which keeps all of Finland inhabited.

Scenarios, the environment and health

One of the crucial questions with respect to the sustainability of the scenarios is how certain they are to reach the emission target set. A and D reach the target with a clear safety margin, whereas B and C only reach the target narrowly. If carbon capture and storage cannot be put to commercial use or if there was a serious nuclear accident somewhere in the world, the paths leaning on these techniques might run into trouble.

In terms of biodiversity, the scenarios have major differences. In scenarios B, C and D, domestic biomass reserves are utilised to the full. This puts pressure towards more intensive use of forests. In scenario D, biomass is also imported from abroad. Scenario A has the least national pressure for economic exploitation of forests; thus, this scenario offers the most opportunities for protection and soft utilisation of forests. On the other hand, scenario C would be better suited to labour-intensive forest management methods.

The environmental impact assessment of the Climate and Energy Strategy states that an efficient selection of means is needed for a situation where the utilisation of forests affects biodiversity more extensively than anticipated. Similar means would be needed in scenarios B, C and D, where forest resources are utilised intensively.

In scenario D, agriculture is downsized radically; this would eradicate biotopes dependent on farming. In scenario C, the additional construction of hydropower in protected water bodies would cause damage to species in rivers. Peat extraction in the scenarios would have an impact on peatland habitats.

The use of biomass and non-renewable energy sources affect the availability of natural resources. Uranium is needed in the scenarios utilising nuclear power; however, the fast-breeder reactor in D reduces this need. Fossil fuels are still used in scenario D. The use of peat is no problem with regard to its continued availability.

Agriculture will pose a smaller burden on water bodies in the scenarios when the use of fertilisers, or agricultural production on the whole, diminishes. Peat extraction may be harmful to water bodies. Nitrogen emissions from traffic decrease significantly in all of the scenarios. There is less condenser water from nuclear power plants when the water is utilised for district heat production in scenarios B and D.

All of the scenarios would improve the health of the population. Since there is less driving and more electric cars, atmospheric pollution and traffic noise are reduced. As everyday physical activity becomes more common in scenarios A and

B, and diets contain more vegetables in scenarios A and C, people's state of health will improve. On the other hand, small-scale use of wood may increase particle emissions harmful to health unless effective combustion techniques are taken into use.

It is hard to estimate the global implications of these scenarios. In all of the scenarios, low-carbon solutions would be developed and taken into use in Finland, and these solutions could help reduce emissions elsewhere in the world, too. For example, energy decisions made in Finland could also encourage other countries to choose similar solutions.

Box 1 Citizens' views on the acceptability of the scenarios

The desirability of the scenarios was tested in an online survey in early 2009. About 1,200 people participated in the survey; the general tone of the responses was positive and solution-oriented.

After the survey, some adjustments were made to the scenarios. The responses therefore do not necessarily apply to the final scenarios. Since the respondents do not constitute a representative sample, the results cannot be generalised for the entire population.

Scenario A was considered the most utopian, but at the same time, respondents hoped that many of its features would be realised. Renewable energy and compact housing gained support, but some respondents were concerned that the urban scenario might alienate people from nature.

Respondents felt that scenario B was the least utopian and fairly close to their own thinking. Many supporters of A also liked B, with the exception of the extensive use of nuclear power. Especially the measures to decrease consumerism and traffic appealed to respondents.

Scenario C was many respondents' favourite, but at the same time it was considered less realistic than A, the other popular scenario. Respondents liked the emphasis on self-sufficiency and locality, renewable energy, and vegetarian and local foods. Critics saw C as a return to the 1950s.

Supporters of scenario D stressed the economy and emphasised the importance of industry, the need for mobility, and the limited availability of renewable energy. Here the gender differences were the most obvious: in practice, only men supported this scenario.

The respondents agreed most on transport and services. It was believed that the share of services will continue to grow, progress will be made in motor vehicle technology, and public transport and bicycle and pedestrian traffic will gain a stronger foothold. Housing, industry, the need for energy, and the ways of producing energy divided opinions the most.

What if?

The future may differ from the paths reviewed – and probably will do so in many respects. It is fairly certain that things no one can yet even imagine will happen by 2050. To be prepared for alternative futures, it is good to weigh up the scenarios against possible events.

What if the economic crisis is prolonged, aggravated and occurs again? A deep economic recession would cut energy consumption, especially in industry, but would also be seen, for instance, as shrinking traffic volumes. Because the recession would reduce emissions, it would be easier to meet strict emission targets in the short run. On the other hand, the financial crisis and companies' economic difficulties would postpone investments in new technology.

What if emission targets become stricter? It is possible that, by 2050, most industrialised countries will be required to be carbon neutral, i.e. to cut their net emissions to zero. In two of the four scenarios drawn up for the foresight report, the emission reductions achieved are already 90 per cent. Carbon neutrality would require the utilisation of bioenergy with carbon capture and storage, larger carbon sinks, and the purchase of emission allowances.

What if technology develops more quickly – or more slowly – than anticipated? If a radical leap is achieved in key technologies – for example, solar power becomes cheaper than carbon-fired condensing power – emission reductions may become considerably easier to attain. On the other hand, if technologies such as electric cars and carbon capture and storage cannot be commercialised, the corresponding paths will become much more difficult.

What if the acceptability of nuclear power falls suddenly? The energy economy of some scenarios is based on the construction of additional nuclear power plants. A major accident abroad could give a serious blow to the political acceptability of nuclear power, as occurred after the accident in Chernobyl. Depending on the timing, this could require substantial changes on some paths.

Table 14 More detailed description of the scenarios

Scenario/ Variable	A: Efficiency Revolution	B: Sustainable Daily Mile	C: Be Self-sufficient	D: Technology is the Key
Economy*	At first, slower growth because of large investments; later, fast growth because of low energy costs.	Fairly steady growth; purchasing power is freed from transport and housing costs to other expenditure.	Slow growth because of choices that reduce productivity.	First fairly rapid growth, then slower growth owing to energy and emission costs.
Regional and urban structure	Regional structure concentrated towards 8–12 strong regional centres. Cohesive urban structure.	Decentralised regional structure, very cohesive urban structure. Service centres surrounded by efficiently built areas.	Regional structure consisting of 20 strong regional centres. Dispersed urban structure, units as self-sufficient as possible.	Regional structure concentrated in Southern Finland. Compact cities surrounded by a dispersed structure. Fewer people living in rural areas.
Housing	New residential buildings are zero-energy houses; old buildings are renovated to be energy-efficient. Eco summer cottages.	Living space per capita at the present level. Shared premises, wood, and new housing forms make the living environment more pleasant.	More living space per capita. Vegetable patches and greenhouses in residential areas. Less need for summer cottages.	Clearly more living space per capita, second homes also common.
Transport	Transport performance has decreased, telework and distance services have reduced the need to travel. Goods transports at present level. Cars consume less than half of the energy they do now; biofuels and electricity. Private cars mostly in rural areas, public transport in and between urban areas.	Transport performance has fallen clearly and energy consumption for transport is cut by half. Less need for goods transports. Daily trips within a radius of a kilometre mostly on foot or by bicycle. Public transport and bicycle and pedestrian traffic between service centres. Train as the principal mode of transport between cities.	Passenger transport performance at the present level, many transports in the forest industry. Passenger traffic in and between major cities largely by rail and hybrid biobuses. Cars run on electricity or domestic biofuels. Less international traffic.	Passenger transport performance in passenger traffic increased, shift to electric cars. Increased transports for industry, partly by rail; transports to the Arctic Ocean. Public transport used to solve congestions. High-speed trains from Helsinki to Oulu and St. Petersburg. Energy-efficient air transport.
Economic structure Industry	A decreased share of industry. Manufacture of metals from virgin materials and a forest industry dependent on purchased energy have been replaced by new products and new knowledge industry (e.g. nano, bio, ICT). New 'Nokias' in climate technology. Renovation of buildings.	Demand for mass consumption products has decreased and been replaced by more individual products and services. Renewal of industry, biorefineries, ICT, industries utilising recycled materials. Ecological construction and a planning are export product.	Forest industry has become a bioindustry. Strong domestic food industry. Mechanical engineering, ICT. Energy self-sufficiency supported by new construction, renovation, and building with wood.	Industry's share at the present level. Energy-efficient knowledge industry (ICT, bio, nano etc.) in southern Finland, industries utilising natural resources (forest, metals, chemical) outside densely populated areas. CCS in the process industry. Construction of single-family houses.

Scenario/ Variable	A: Efficiency Revolution	B: Sustainable Daily Mile	C: Be Self-sufficient	D: Technology is the Key
Services	Share increased clearly, especially leisure, cultural, health and well-being services. Extensive private service market. Low-carbon consultation and immaterial innovations for exports. New service sectors.	A sharp increase in neighbourhood services. Small schools, libraries and shops. Hypermarkets have disappeared. Logistics that minimises the transport demand; support services for business. Nutritional, fitness and well-being services. Rented summer cottages.	More neighbourhood services. Consultation on decentralised energy solutions and energy efficiency for exports. Many local SMEs and cooperatives. Domestic travel.	Moderate rise in the share of services. Services that support industry in Finland and for exports. Construction of transport infrastructure. Strong tourism especially in the north, trading and transport services.
Primary production	Share of primary production continues to decline. More organic production in agriculture. Diminished, centralised meat production.	Share of primary production declined slightly. Local food a growing sector, more organic production.	Share risen slightly. Local and organic food, small-scale forestry and fishing as growing sectors. Local meat production.	Agriculture declined clearly. More mining, uranium mines. Forestry to meet the needs of industry. Synthetic meat.
Energy Demand	Consumption halved, radical improvements in efficiency in all sectors. Strong demand response. Trigeneration (electricity, heating, refrigeration).	Consumption fallen by one quarter. Industry's demand roughly at the present level. Clearly less energy needed for transport and housing. Consumption electrified.	Consumption fallen by one third. Homes produce their own energy in sparsely-populated areas and in new areas. Comsumption by households and trips abroad has fallen clearly.	Consumption at the present level. Increased consumption by industry and transport. Intelligent household appliances and electric cars even out demand peaks. Consumption electrified.
Production**	All energy produced with renewables; biomass and wind the most important sources. International energy trade, e.g. wind power from the North Sea (supergrid).	Two thirds renewables, two fifths nuclear power. Condenser water from nuclear power plants used for heating.	Energy produced in Finland, four fifths renewables. Decentralised small-scale production, new hydropower, bio-CHP. CCS-peat. Nuclear power for the needs of industry, share fallen.	Renewables three fifths. Steep increase in nuclear power (incl. fast-breeder reactors). Fossil fuels and peat in large CCS facilities. Electricity for exports. Waste incineration.
Values and lifestyles	Telework has become more common, less travel to distant locations. Trips to the outdoors, cycling, virtual travel. Vegetarian diets more common. Appreciation for services, sustainability and well-being.	Increased appreciation for free time and community spirit, life at hand. Materialism and consumer culture discarded.	Self-sufficiency and locality. Manual skills and proximity to nature in high regard. Telework has become more common. Vegetables and seasonal foods more common in the diet.	Appreciation for efficiency, ease in daily life and quality. International outlook. Individualism, eco-materialism.

* The assumptions about economic trends were made before computation and analysis. The effects of the various scenarios on economic trends have been assessed in the section "Comparison of paths in terms of the economy" in this appendix.

** Energy/production: shares of renewable energy corrected in scenarios B, C and D in this table on 26 October 2009

All scenarios share the following features

- Finland's emissions are reduced by at least 80 per cent from the 1990 level by 2050.
- International climate negotiations have progressed, and other countries also restrict their emissions.
- Global warming follows the two-degree path.
- Worldwide technological development is rapid.
- Energy efficiency improves in all sectors.

The following issues have been handled separately:

- International emissions trading: It is assumed that emission reductions are implemented through domestic measures.
- Policy on sinks: Sinks in forests and soil have been excluded from the review.
- Greenhouse gases: Calculations have been limited to the gases covered by the Kyoto Protocol (carbon dioxide, methane, nitrous oxide and F-gases).

Appendix 2: Preparation of the foresight report and background studies

Group of experts, 21 September 2007–

Oras Tynkkynen, Government Climate Policy Specialist,
Chairperson

Pertti Anttinen, Head of Unit, Ministry for Foreign Affairs
Outi Berghäll, Director, Ministry of the Environment (until 1 October 2008)
Nina Broadstreet, Senior Adviser, Ministry of Employment and the Economy (until 1 October 2008)
Santtu von Bruun, Futures Researcher, Association of Finnish Local and Regional Authorities
Sirkka Hautojärvi, Permanent Secretary, Ministry of the Environment (until 1 October 2008)
Marja Jallinoja, Chairman, Finnish Air Pollution Prevention Society
Tuuli Kaskinen, Climate Specialist, Finnish Association for Nature Conservation
Anna Korppoo, Senior Researcher, Finnish Institute of International Affairs (from 1 October 2008)
Matti Liski, Professor, Helsinki School of Economics
Peter Lund, Professor, Helsinki University of Technology
Hannele Pokka, Permanent Secretary, Ministry of the Environment (from 1 October 2008)
Sirpa Smolsky, Managing Director, Association of Finnish Steel and Metal Producers
Petteri Taalas, Director General, Finnish Meteorological Institute
Pekka Tervo, Senior Adviser, Ministry of Employment and the Economy (from 1 October 2008)
Sami Tuhkanen, Development Manager, Sitra, the Finnish Innovation Fund

Secretary to the group
Pirkko Heikinheimo, Project Manager, Prime Minister's Office

Meetings and participation of stakeholders and citizens

Ministerial working group

Kick-off seminar, 10 October 2007
Scenario workshop, 25 November 2008
18 meetings

Group of experts

2 retreats
20 meetings

Participation of citizens and stakeholders

Online discussion at the government online discussion forum otakantaa.fi, December 2007
Online discussion at the otakantaa.fi forum, 5 March 2009
Scenario workshops, 20 October and 19 November 2008
Online surveys during the preparatory phase of scenarios, October and November 2008
Online survey on draft scenarios, January 2009

Stakeholder panels and joint discussion (17 March – 9 June 2008, 14 meetings in total)

- Energy-intensive industry
- Youth and student organisations
- Environmental and development cooperation organisations
- Producers of new technology
- Labour organisations
- SMEs
- Research
- Services
- Rural areas
- Municipalities and the regions
- Well-being and disadvantaged people
- Energy producers
- Worldviews

Press conferences and seminars

Energy efficiency seminar, 5 August 2008
Sustainable transport seminar, 17 September 2008

Dates of publication of background reports to the foresight report

- 25 August 2008: 'The two-degree climate target – what risks are avoided, how much should emissions be reduced', 'A review of scenarios', and 'Nonlinear and extreme climate changes'
- 9 September 2008: 'Change in climate attitudes and the agents of change'
- 12 September 2008: 'Labels for indicating the climate impacts of products'
- 5 November 2008: 'Effective climate policy' and 'Benefits of emission limitations in countries outside the limitation schemes'
- 18 November 2008: 'Climate policy and regions' and 'Climate policy and income distribution'

Expert workshops

Foresight report and development paths, 28 January 2008
Mainstreaming climate policy and policy coherence, 16 May 2008
Carbon stocks and sinks, 7 May 2009
International climate policy, 16 June 2009

Scenarios and the economic structure, 12 November 2008
Scenarios and development of technology, 14 January 2009
Scenarios and extreme climate changes, 26 January 2009
Scenario assessment workshops, 11 March 2009 and 16 June 2009

Joint meetings with contact persons from ministries during the report's circulation for comments (altogether four meetings between 20 January and 3 March 2009)

Background reports to the foresight report (extended summaries available in English at www.vnk.fi/foresightreport)

Ilmastopolitiikan valtavirtaistaminen ja politiikkakoherenssi
(Mainstreaming climate policy and policy coherence)
Prime Minister's Office Publications 6/2008 (entire report available in English)

Ilmastoasenteiden muutos ja muuttajat (Change in climate attitudes and the agents of change)
Prime Minister's Office Publications 9/2008

Tuotteiden ilmastovaikutuksista kertovat merkit (Labels for indicating the climate impacts of products)
Prime Minister's Office Publications 11/2008

Kahden asteen ilmastotavoite – mitä riskejä vältetään, miten paljon päästöjä tulee vähentää (The two-degree climate target – what risks are avoided, how much should emissions be reduced)
Prime Minister's Office Publications 13/2008

Epälineaariset ja äärimmäiset ilmastonmuutokset (Nonlinear and extreme climate changes)
Prime Minister's Office Publications 14/2008

Skenaariokatsaus. Skenaariot pitkän aikavälin ilmastopolitiikan laadinnassa. (A review of scenarios. Scenarios in the drafting of long-range climate policy.)
Prime Minister's Office Publications 15/2008

Selvitys Ison-Britannian ilmastolakiehdotuksesta ja alustava arvio vastaavan sääntelyn soveltuvuudesta Suomen oikeusjärjestelmään (Review of the Climate Change Bill introduced in the UK and a preliminary assessment of the applicability of similar regulation to the Finnish legal system)
Prime Minister's Office Publications 16/2008

Päästörajoitusten ilmastohyödyt rajoitusten ulkopuolisissa maissa (Benefits of emission restrictions to the climate of countries outside the scope of the restrictions)
Prime Minister's Office Publications 17/2008

Tehokas ilmastopolitiikka (Effective climate policy)
Prime Minister's Office Publications 18/2008

Ilmastopolitiikka ja tulonjako (Climate policy and income distribution)
Prime Minister's Office Publications 22/2008

Ilmastopolitiikka ja alueet (Climate policy and the regions)
Prime Minister's Office Publications 23/2008

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