TEK & UIL

Engineering Associations' National Climate Plan for Finland

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THE FINNISH ASSOCIATION OF GRADUATE ENGINEERS TEK

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SISÄLLYSLUETTELO

ABBREVIATIONS, UNITS AND CONCEPTS

CCS Carbon Capture and Storage

CHP Combined generation of heat and electricity (Combined Heat and Power)

CO2 Carbon dioxide

IPCC Intergovernmental Panel on Climate Change

W Watt, unit of power, indicates the amount of energy of the work done or used within a specified period of time, 1 W = 1 J/s

kW kilowatt = 1000 W

MW megawatt = 1000 kW = 1 000 000 W

GW gigawatt = 1000 MW = 1 000 000 000 W

TW terawatt = 1000 GW = 1 000 000 000 000 W

Wh watt hour, unit of amount of electricity, also used of amount of electricity, output multiplied by time

kWh kilowatt hour = 1000 Wh

MWh megawatt hour = 1000 kWh = 1 000 000 Wh = 3.6 GJ

GWh gigawatt hour = 1000 MWh = 1 000 000 kWh = 3.6 TJ

TWh terawatt hour = 1000 GWh = 1 000 000 MWh = 1 000 000 000 kWh = 3.6 PJ

J Joule is the SI system's unit of energy, 1 J = Ws

MJ megajoule = 1 000 000 J = 0.2778 kWh

GJ gigajoule = 1 000 MJ = 0.2778 MWh

PJ petajoule = 0.2778 TWh

Joule is the SI system's unit of energy. The amount of electricity is commonly expressed in watt hours. To facilitate comparison, both units are used in this report so that the commonly used unit is given first and it is then followed by the value converted into the second unit.

Nominal output The output given by the manufacturer indicating the maximum that the device is able to produce.

Annual production Amount of energy produced by a plant in a year. For example, in the case of wind power, about one third of what the plant would produce when operating at full capacity.

Regulation power Capacity by means of the production of electricity is regulated to correspond to variable consumption.

Reserve power A plant can be shut down for various reasons, e.g. maintenance or a wind-power plant because there is not enough wind or too much of it. The backup system substituting for absent production capacity is called reserve power.

1 INTRODUCTION

In the international project titled Future Climate – Engineering Solutions being implemented by various engineering organisations, the associations of each participant country have drawn up the profession's proposal for their country's national climate programme, wherein national structures are analysed and technology-based means for cutting emissions and for slowing down climate change are presented. Because the problem is a global one, also global methods are needed to solve it, but in this assessment the focus is on national solutions.

Technology plays a central role in safeguarding the well-being of people and the environment, and in enabling sustainable development. Solving the challenges of climate change can also affect the image that the public has of the actors representing the field of technology. Technology is not just about new technical devices; it is also about advanced processes and the organising of functions involved in the acquiring and application of new techniques, and making them available for commercial use. Technology provides opportunities for creating competitive edge based on accountable operation and research and development practised with due consideration for the environment. Climate change impacts not only on the development of technology, but also on the contents of higher education in the field of technology and on the further education of professionals in this field.

Nationally available solutions and their effects on reducing greenhouse gas emissions and on the slowing down of climate change have been studied in the course of the project. The objective is to reach such a level that global warming does not exceed 2°C compared to pre-industrial times. It is estimated that this will require, by the time we reach the year 2050, greenhouse gas emissions to have been reduced by 50%-85% from their level in 2000. The methods enabled by technology play significant roles in our endeavour to achieve the reductions in greenhouse gas emissions. The technology for reducing emissions exists. However, large inputs in research and product development are still needed if we are to develop more efficient means of reducing emissions to the required level.

The international project involves using national programmes as the basis for preparing engineers' organisations' common recommendations for technology-based means of reducing emissions and slowing down of climate change. These recommendations will also be presented in Copenhagen in December 2009 to the UN Climate Change Convention.

The project's participants represent organisations from a total of 12 countries; Finland, Denmark, Sweden, Norway, Germany, India, Great Britain, Unites States, Japan, Australia, Ireland, and Bulgaria. Finland's contribution was drawn up in collaboration by the Finnish Association of Graduate Engineers TEK and the Union of Professional Engineers in Finland UIL.

1.1 SOME BASIC PREMISES

Securing the generation and availability of the energy are matters of particular importance when considering Finland's climatic conditions. Considering the climate objectives and long-term development, it is absolutely necessary to bring to an end the direct link between the improvement in the standard of living and growth in energy consumption based on fossil fuels. Chapter 3 of this assessment looks at the different energy-generation options, the proposals pertaining to them, and the effects on the overall situation.

From the point of view of the impacts on climate, the consumption of energy and efficiency of energy use, along with generation, are of decisive importance. In regard to energy efficiency, the June 2009 report of the Energy Efficiency Committee, appointed by the Ministry of Employment and the Economy, sets out a host of measures enabling energy efficiency to be significantly improved during the period under review. The present report, also, presents some of these. In addition, Chapter 4 presents some other special measures in the implementation of which the Government has a crucial role.

The basic assumptions in the assessment are ensuring conditions favourable to job-providing business in Finland and the establishing of a functioning and acceptable emissions trade system. The premise for the undertaking is that only a model ensuring the moderate development of the standard of living and competitiveness is feasible in a real world if we are to avoid a major social crisis. Among others, agriculture has been omitted from this assessment and thus its effects on the development of emissions have not been taken into consideration.

The estimates presented around the world regarding the development of the price of oil vary greatly. It is assumed that the global market prices for oil, coal, and natural gas will, in the long term, rise clearly above the average of the last ten years. This will improve the competitiveness of renewable energy sources. It is believed that the average price level of emission rights will settle at €30–40 /ttCO2.

The premise is a national one, i.e. the issue at stake is that of the measures to be implemented in Finland for the emission objectives to be reached. However, the problem is a global one. Industrialised countries must do their part in cutting emissions. The global ecosystem cannot withstand a situation where the path of developing countries towards greater prosperity follows that previously taken by the present industrialised countries. Achieving a globally sustainable situation requires that we are able to demonstrate credible alternative solutions to the developing countries. These solutions depend on the solutions to be done now in industrialised countries. Prosperous Finland has a duty to invest in such energy technology as can be safely used everywhere in the world. The keys to this solution are to be largely found in technology and its development. In Finland, too, this global frame of reference can provide the necessary preconditions for activity which would find its main applications elsewhere.

Due to the international nature of the problem, there are grounds for expecting that Finnish actors should be provided with opportunities for benefiting from cost-efficient flexibility mechanisms also outside of Finland, either as buyers or as sellers, and to benefit from the emission reductions.

2 THE PRESENT SITUATION

When comparing the greenhouse gas emissions of various countries, it is necessary to also take into consideration national conditions, which are characterized by some major differences. For example, the heating need of buildings in Southern Europe differs greatly from what it is in the Nordic Countries. Moreover, the transportation distances to the markets are considerably shorter from Central Europe than from the Nordic Countries. The industrial structure also has major impacts on the emissions of a country.

Also, the economic recession temporarily affects the consumption of energy and emissions. The present assessment does not address the matter of the effects of the economic recession.

2.1 CONDITIONS IN FINLAND

The special characteristics of Finland include the above-average need for heating energy because of the cold climate and the long transportation distances to the main markets caused by the country's geographical location and the long internal distances. Finland's industries are also very energy-intensive. In 2007, the country's industries accounted for 53% of the total consumption of electricity in Finland.

According to Teknologiateollisuus ry (Federation of Technology Industries) Finland produces paper to meet the needs of 100 million people, wood-based products to meet the needs of 50 million people, and steel to meet the needs of 40 million people. These figures have been arrived at by dividing the total global production with the total inhabitants of the world, and by then seeing the proportion whose needs are satisfied by production originating from Finland. Indeed, Finland is highly reliant on export income: 45% of Finland's GNP is export-oriented. More than 80% of the electricity consumed by industries goes into the manufacturing of export products. Consequently, more than 40% of the electricity consumed in Finland goes into the manufacturing of export products.

The per capita emissions affect the various countries very unevenly. Considering this, it is better to use nominal emissions (e.g. emissions per produced tonne or per transported kilometre) to enable comparability of emissions. When applying the concept of nominal emissions, it is also possible to compare the effectiveness of operation, which is not the case in the per capita line of thinking.

2.2 FINLAND'S ENERGY CONSUMPTION

The year 2007 has been chosen by international engineers' organisations as the comparison year for the Future Climate project as comprehensive statistical data are already available for this year. At that time, the total consumption of energy in Finland was about 1470 petajoules (PJ), i.e. 408 terawatt-hours (TWh) according to Statistics Finland. The total consumption of electricity in 2007 was 90.4 TWh (325 PJ). Figure 1. Total consumption of energy and emissions of carbon dioxide in Finland in 1990 – 2007. [1]

2.3 FINLAND'S GREENHOUSE GAS EMISSIONS

Finland's greenhouse gas emissions in 2007 amounted to 78.3 million tonnes of carbon dioxide, which is about 2% less than in the previous year. The emissions in 2007 exceeded by more than 10% the target level of the commitment period (2008 – 2012) of the Kyoto Protocol. Moreover, Finland's emissions have, during the past five reporting years, been close to an average of 7.5 million tonnes, i.e. 10% above the allowed emission level (71 million tonnes) of the Kyoto Protocol. The annual variation in these emissions has been considerable. Especially the availability of hydroelectric power in the Nordic electricity market, importing of electrical power from Russia, and annual structure and volume of domestic power generation have caused this variation. The emissions from the energy sector, which dominates in regard to emissions, decreased by less than 3% in 2007 when compared to 2006. Figure 2 shows Finland's greenhouse gas emissions by sector in 2007. [2]

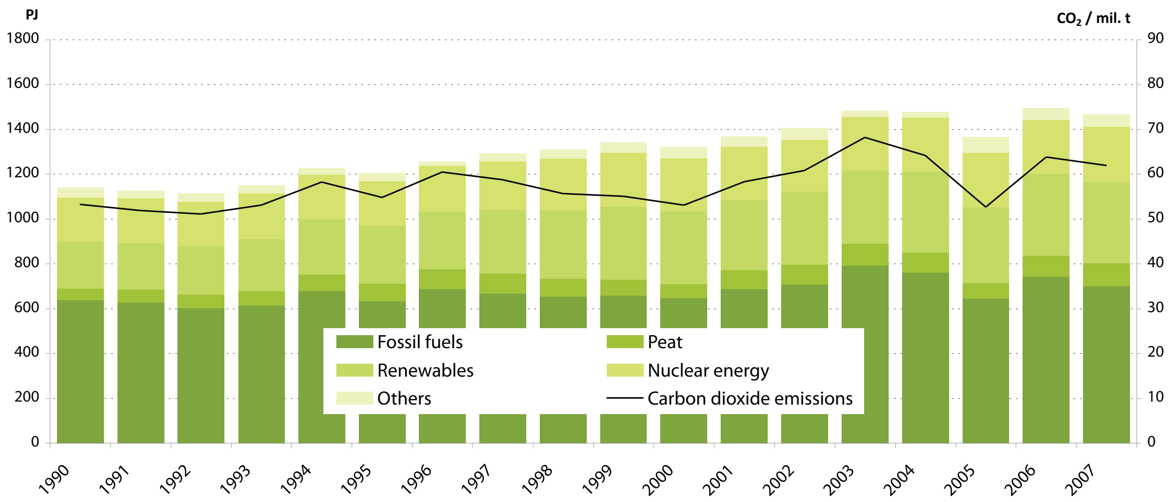

Figure 1. Total consumption of energy and the energy sector's emissions of carbon dioxide in Finland in 1990 – 2007. Source: Statistics Finland

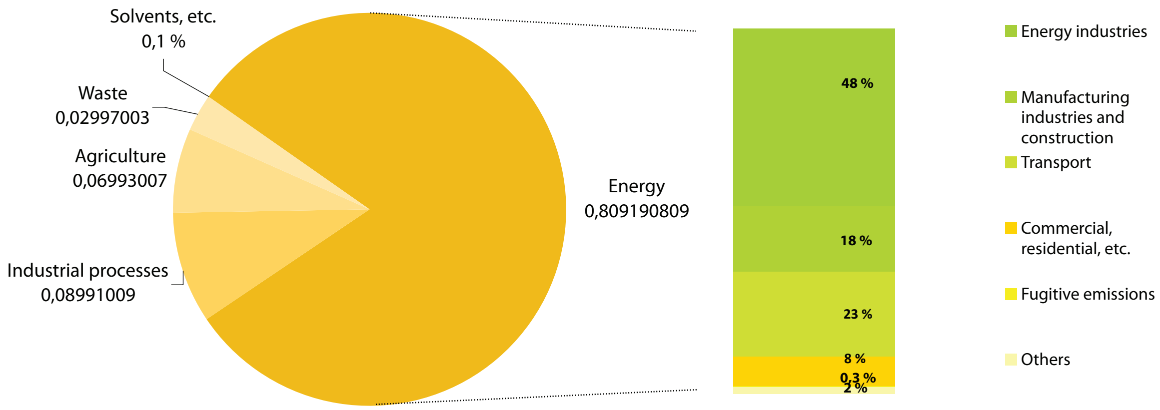

Figure 2. Finland's greenhouse gas emissions by sector in 2007 (%). Source: Statistics Finland

3 REDUCTION OF EMISSIONS IN THE VARIOUS SECTORS

This chapter looks at the various methods and technologies enabling reduction of greenhouse gas emissions and their estimated or recommended development up to 2050. In order that the emissions reduction objectives might be reached, we need to use several methods side by side, and this means that reaching the objectives does not necessarily require the full-scale use of all the methods.

The various means of reducing emissions are divided into four main categories: energy generation (electricity and heat), traffic, industry, building, and living. In addition to these, the chapter addresses actions whereby the government is able to promote the development and introduction of low-emission technology and changes in individual persons' consumer habits. The emissions development achievable by the year 2050 by applying the measures presented in the following subsection is described at the end of this chapter.

3.1 ENERGY CONSUMPTION

3.1.1 CONSUMPTION OF ELECTRICITY

The growth in the consumption of electricity in Finland will clearly slow down compared to earlier years thanks to improvement in energy efficiency, restructuring of the industrial sector, technological development, and renewing of equipment. The consumption of electricity is estimated to reach approx. 96 TWh (346 PJ) by the year 2020.

This assessment is based on the system being dimensioned to have such a capacity as will definitely suffice and enable supply reliability. Finland's domestic generation capacity has to be able to cover consumption peaks and possible fault situations. The consumption of electricity is being gradually increased also by the gradual shift away from using fossil fuels as a result of rechargeable hybrid vehicles and fully-electric vehicles are being introduced. Moreover, the increasing use of heat pumps is increasing the demand for electricity. Thus, increasing electricity consumption does not necessarily mean increasing need fro primary energy; instead, part of the increase in electricity consumption is replacing other energy end consumption. Two assumptions in this assessment are that electricity consumption in 2020 will be slightly less than 100 TWh and that it will grow to over 100 TWh by the year 2030.

3.1.2 ENERGY CONSUMPTION BY SECTOR

Structural changes in the industrial sector can have quite significant impacts on the consumption figures. However, this assessment should not be understood to constitute a statement on the desirable development trends for Finland's industrial structure. However, one of the premises of this assessment is that of ensuring the preconditions for industrial and commercial activity in Finland. During the years 2008 – 2009, consumption by industries has considerably diminished. Part of this change is caused by economic fluctuations, and another part is caused by structural change. The first of the two will come back when the trade cycle situation improves, the latter will not. Long-term planning cannot be based on rapidly changing economic situation; instead, it must be possible to separate their impact from structural changes. This estimate includes the assumption that the consumption by conventional forest industries will diminish. However, a considerable proportion of the electricity consumption freed by reduced consumption will most probably be replaced by the electricity consumption required when producing biofuels.

The nominal consumption of heating energy by the stock of buildings (kWh/m3) will diminish. However, the building volume will simultaneously increase as the spaciousness of swellings and the number of households increases, and the building of commercial and recreational centres and other leisure-time facilities increases. This means that the total consumption of heating energy may even increase from what it is at the present.

Traffic emissions account for nearly 20% of Finland's greenhouse gas emissions and for this reason there is significant potential for reduction in this sector. Given the current trend, the nominal consumption of traffic will diminish, but as the passenger-/tonne-kilometrage statistics increase, traffic emissions will remain roughly unchanged. On the other hand, the shift away from using fossil fuels and adopting hybrid and electric vehicles will gradually reduce the final consumption of traffic.

The consumption of electricity by households has increased continuously. During the years 2000 – 2005, consumption increased by about 14%, and in 2005 it exceeded 10 TWh (36 PJ). A significant part of the growth is caused by increased consumption coming from single-family houses. As homes become larger and as their level of equipping improves, consumption also increases. The electricity consumption of refrigeration devices is on the decrease, but the consumption coming from consumer electronics equipment has undergone a powerful increase. [3]

Figure 3 shows the energy consumption by sector from during the period 1990 – 2000 and the estimate of future development up to 2050. The item "Others"contains the use of electricity and fuels by households, public and private service sector, agriculture, forestry, and the building industry. The total consumption of this sector is predicted to be remain unchanged, even though internal changes may take place in it.

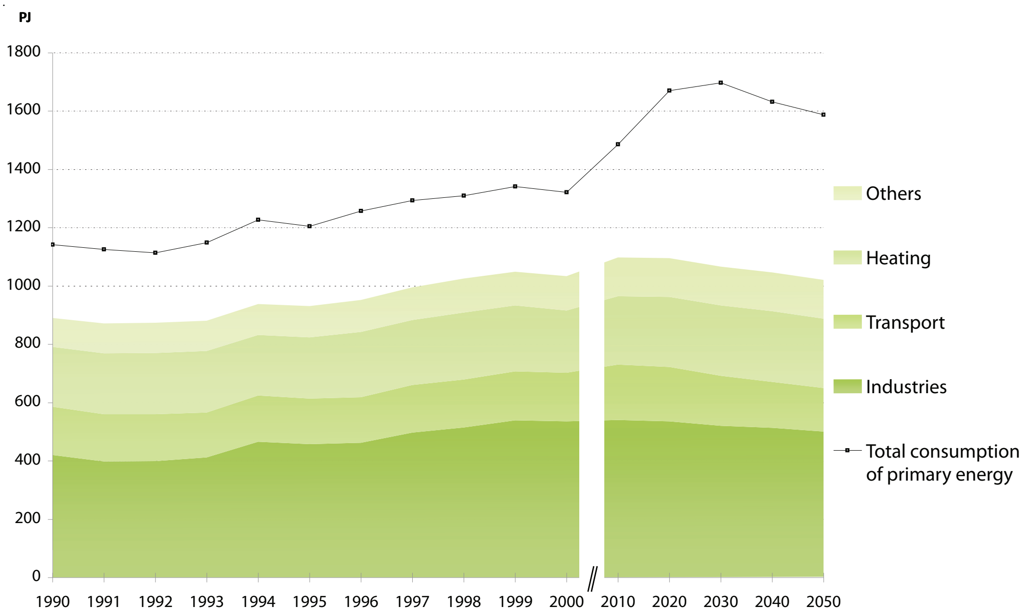

Figure 3. Final consumption of energy by sector and total consumption during the period 1990 – 2050 Source of information for period 1990 – 2002: Statistics Finland.

3.1.3 TOTAL CONSUMPTION OF ENERGY

This assessment is based on an estimate according to which the total consumption of primary energy in Finland can rise to as much as 1700 PJ (approx. 470 TWh) in 2030, and then take a downward trend. The use of fossil fuels in the estimate will considerably diminish; to less than one third of its 2007 level. The most significant increase is in the share of nuclear power. Also the use of the bioenergy will increase and reach its peak in 2030, and then stay at that level thereafter. In addition to the above, the generation of wind power and hydro-power and the use of waste in generating energy, and the use of heat pumps will increase. Figure 4 shows the estimated development of the total consumption of primary energy by energy source during the period 2007 – 2050.

The energy consumption estimate is smaller than some other estimates presented during the past few years. However, according to our present knowledge, it is sufficient to ensure that the availability of energy does not form an insurmountable obstacle to the increase in general well-being in Finland.

The development of the global economy and the improved degree of utilisation of energy affect future development. If we are able to fully implement the recommendations of the Energy Efficiency Committee successful, the consumption of primary energy may stay at a level slightly below that which has been anticipated. If this happens, it will have a favourable impact on Finland emissions of greenhouse gases.

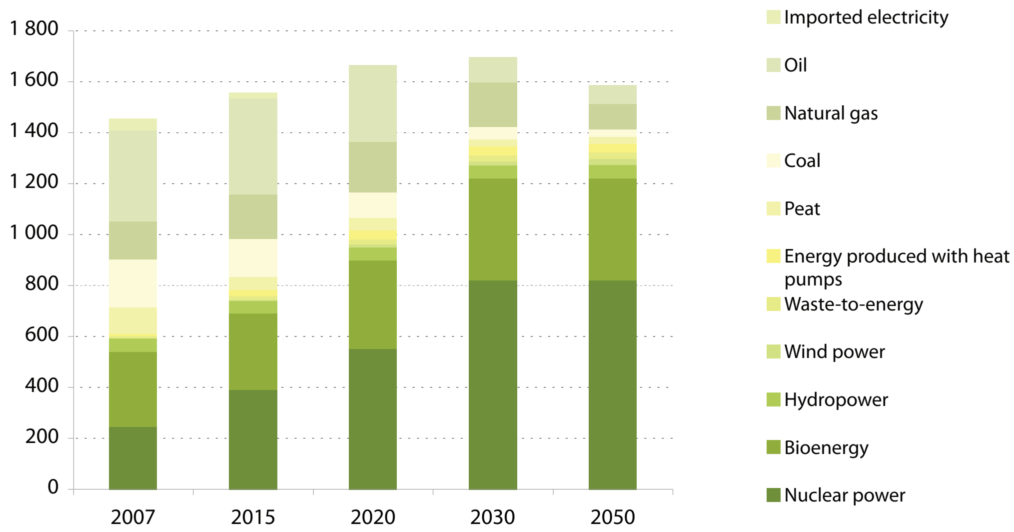

Figure 4. Estimated total consumption (PJ) of primary energy by energy source.

3.2 ENERGY GENERATION

When assessing the development of the various forms of energy generation and of generation need, it is assumed that the total consumption of energy in Finland will increase in the way set out above in Section 3.1. This assessment is also based on the assumption that net imports of electricity will gradually decrease and entirely end by 2020, perhaps even earlier. Therefore, new energy generation capacity is needed, especially in the generation of electricity.

3.2.1 NUCLEAR POWER

The current nuclear power plants operating in Finland, Loviisa 1 & 2 and Olkiluoto 1 & 2, have a combined electricity generation capacity of 2700 MW. Once Olkiluoto 3 is completed and running, the combined capacity will be 4300 MW. Three applications have been submitted for new nuclear power plants. Of these, TVO's Olkiluoto 4 is designed to have a capacity of 1450 – 1650 MW and Fortum's Loviisa 3 is designed to be 1000 – 1800 MW in capacity. Fennovoima envisages building either one big one or two smaller units depending on the site and the plant type. Fennovoima's plant is designed to have a capacity of 1500 – 2500 MW.

The assumption in this climate programme's calculations for electricity generation and emissions is that Olkiluoto 3 will be in operation in 2012, which means that the total output will then be 4300 MW. A further assumption is that by 2020 there will be at least one new unit running, which means that the generation capacity then will be approx. 6000 MW. By the year 2030, the total generation capacity, following the going on-stream of the new units and modernisation of the old units, will be 8000 MW. This figure also takes note of the fact that Loviisa 1 & 2 units will no longer be running then.

3.2.2 HYDROELECTRIC POWER

The fastest and most profitable means of promoting the use of hydroelectric power is to make maximum use of the potential in the existing built-up water systems and of the additional capacity available through refurbishing of the associated equipment. Various estimates indicate that the additional capacity to be achieved this way amounts to about 365 MW. Small and mini hydroelectric power has the potential for an additional 100 MW by the year 2020 and 240 MW by the year 2050. [4]

The exploiting of the aforementioned potential will lead to a total anticipated hydroelectric power generation capacity of 3500 MW by the year 2020 and 3650 MW by the year 2050. In addition to the above, protected water ways represent a potential of nearly 1300 MW. All water systems should not be harnessed for the purpose of generating hydroelectric power; the environmental and recreational value of water systems must also be taken into consideration.

3.2.3 WIND POWER

It is estimated that the production capacity of the wind power can be increased from the present little over 100 MW to 1500 MW by the year 2020, and to 4000 MW by the year 2050. In addition to being available from extensive wind parks, wind power can be obtained through small-scale applications.

The possibilities for adding to the generation of wind power are bound to improve as the size of wind-power plants increases and as the competitiveness of wind power improves. The disadvantage associated with wind power is that it needs reserve and regulating power to support it, e.g. hydropower. Wind power generation requires subsidies from society, either in the form of investment subsidies, operating subsidies or via supply tariffs.

3.2.4 SOLAR ENERGY

The use of the solar energy in Finland is marginal, and its nationwide share is not expected to increase significantly. The annual solar radiation is not adequate in Finland for focusing solar energy power plants to be built here. However, the use of solar electricity and solar heating panels will probably increase. Solar energy along with small-scale wind power capturing can be made very good use of in connection with holiday homes, for example. These are used mainly during the summer when the generation of both sun-based and wind-based power is ensured. In winter, when there is little generation of these energy forms, consumption is also at its minimum in holiday homes.

Worldwide, solar power can have even a significant role, and it possesses a huge potential when considering technological innovations. Finland can participate in this global development by exporting know-how and technology related to solar power to places where it can be more made use of more efficiently than is possible in Finland.

3.2.5 WASTE INTO ENERGY

The point of departure is primarily to endeavour to prevent waste from being formed. Enabling efficient waste utilisation recycling presupposes further inputs in sorting and processing systems. Advisory services also have an important role in transforming consumers' attitudes and habits in the direction of producing less waste and efficient recycling and sorting of the waste that is formed. Preventing waste from being formed and increasing recycling are the primary means whereby methane emissions can be reduced in connection with waste disposal.

The significance of waste in energy generation depends significantly on the applied technology. The efficiency of outmoded mixed-burning of waste in grate boilers is a relatively poor solution; it is more a matter of waste disposal than resolving an energy issue. However, when using more advanced technology, e.g. gasification, a considerably better efficiency is achieved, and this also means that the amount of energy obtained is greater.

Large power plants using advanced technology should be favoured as far as possible in using waste as an energy source. The building of such plants is probably most likely in the vicinity of population centres.

By making efficient use of advanced generation and combustion technology, it becomes possible to achieve the maximum in utilisation of recycling and waste fuels, approx. 25 PJ (7 TWh), by about the year 2030, after which the use of waste for energy generation will probably stay at the same level.

In the endeavour to reduce the amount of waste formed, a study should be conducted to determine whether to introduce fees based on the amount of waste or to adopt some kind of an economic incentive. This would result at least in a decrease in unnecessary packaging and it would improve the degree of filling of packages and thereby reduce the amount of waste.

The production of waste-based fuels, e.g. biogas and bio-ethanol, will be utilised by investing also in the small plants insofar it is technically and economically feasible. In this sector, too, there are export markets for Finnish production know-how, and for hardware and system suppliers.

3.2.6 BIOMASS

Finland and Sweden are the world's two leading users of bioenergy. Most of Finland's bioenergy is generated in high-efficiency CHP plants operated by various industries and communities. The use of forest chips can be increased to approx. 100 PJ (28 TWh) by the year 2050. There is even more potential, but factors such as long transportation distances impose restrictions. When dealing with the subject of using forest chips, one must bear the geographical distances in mind. The locations where forest chips are in abundant supply are not always sufficiently close to consumption points. If prices and emissions restrictions change radically, even longer transportation distances will become feasible.

Increasing the use of wood should be done with due consideration for the wholeness, and the advantages and the disadvantages. Everything that is collected and taken away from the forest means loss of nutrients, and affects the need for fertilisation and impacts on Nature's biodiversity.

3.2.7 COAL

The use of the coal in energy generation is expected to decrease and the share of electricity generated using coal is expected to decrease from the present 10+ TWh (36 PJ) to about 2 TWh (7 PJ) by the year 2020. Coal-fired power plants will be converted to run on other fuels as well. Other biofuels can also be used to operate coal dust boilers, e.g. by grinding pellets in coal grinding plants or by feeding boilers with biomass of small particle size, e.g. sawdust. An even more efficient solution in terms of its energy generation is to connect a carburettor to a coal-fired boiler and the gas from the carburettor is then fed into the boiler. This technology has been successfully used for more than ten years in Finland on a versatile fuel base. This solution has enabled significant reductions in the use of coal and thereby also a reduction in greenhouse gas emissions.

3.2.8 COMBINED HEAT AND POWER GENERATION

Combined heat and power (CHP) generation has a very high total efficiency and exploiting CHP is highly recommended. A large proportion of CHP's potential is already in use in Finland, and consequently it will not be possible to significantly add to it. However, all of this potential is worth exploiting. Here, too, geography imposes restrictions as an adequate heat load is required near the plant. Small-scale generation could be increased, but its profitable establishing may require subsidies as is the case with wind power. There is unexploited potential also in increasing the rate of building of soda recovery boilers.

There is a lot of expertise in Finland related to co-generation of electric power and heat energy, and China, for example, has a lot of potential for implementation of CHP generation. Finns could export their expertise, and in this way, too, help in reducing emissions.

3.2.9 RECOVERY OF CO2

Some major expectations have been set on the capturing and storage of CO2 (CCS) as a means of reducing emissions. CO2 can be captured either from combustion gases or before combustion in connection with gasification of solid fuels, for example, in which case the product gas burned is mainly hydrogen. However, this is an expensive method and large-scale experience of its application is still lacking. And recovery does also involve lower rate of utilisation of power plants.

The use of coal in Finland will diminish to such an extent that the capturing of CO2 in these conditions will not result in significant reduction of emissions. Moreover, Finland lacks suitable storage sites for CO2. Elsewhere in the world, coal will continue to be used for many years to come, and so capturing CO2 is a feasible alternative in the endeavour to reduce emissions. There is good reason for continuing to invest in developing CO2 sequestration and capturing technology in Finland as well. This technology and the associated expertise can be exported. For example, Finland has significant suppliers of hardware in the fields of energy and off-shore technology, and these products can be utilised also in the capturing and storage of carbon.

3.3 TRAFFIC

Traffic emissions account for nearly 20% of Finland's greenhouse gas emissions and for this reason there is significant potential for reduction in this sector. Given the current trend, the nominal consumption of traffic will diminish, but as the passenger-/tonne-kilometrage statistics increase, traffic emissions will remain roughly unchanged. The following is a review of the means of reducing traffic volumes and of replacing fossil fuels in traffic.

3.3.1 REDUCING VOLUME OF TRAFFIC

Private motoring must be reduced and people need to start using public transport in greater numbers. For people to adopt public transport instead of their own cars, the use of properly functioning public transport must be made inexpensive as well as attractive in terms of routes and timetables. The use of public transport can be promoted also by investing in the development of automated rail traffic in densely-populated areas. The use of public transport is not always possible and then car-pooling needs to be promoted.

Traffic volumes and the energy consumption of vehicles can be reduced also by means of vehicle taxes based on the distances driven. The technical realisation can be based on, for example, locating of the vehicle, and it can be applied to all vehicles irrespective of the energy form used. In its simplest form, shifting the point of focus of the tax becomes possible by reducing the vehicle tax and raising the fuel tax. Motorists can persuaded to use public transport and car-pooling during rush hours.

The urban structure has a decisive impact on the volume of traffic. More about this in Section 3.4.

The need for commuting related to the work can be greatly reduced by promoting teleworking opportunities. Where rational, employees should be offered the option of doing part of their work from a remote location. Data communications solutions and available IT services can be applied in significantly facilitating teleworking. Another possibility is to make greater use of teleconferencing technology in reducing the need to travel and thereby in reducing the greenhouse gas emissions of traffic.

3.3.2 SUBSTITUTES FOR FOSSIL FUELS

The use of fossil fuels will significantly decrease. With outmoded cars being decommissioned and technological advances being made, the emissions from conventional combustion engines will also decrease. In addition, developments such ash increased use of biodiesel and ethanol made from bio-waste means that fossil fuels are being replaced and traffic emissions are reduced. In Finland, there is a lot production know-how related to biofuels, and this expertise can also be exported. In addition to biofuels, the introduction of hybrid cars and electric cars has the effect of reducing the need for fossil fuels.

In the short term, the renewing of the stock of cars on the roads, in regard to both company cars as well as privately owned cars, can be steered through taxation measures favouring low-emission cars. The scrapping of outmoded and inefficient vehicles is being accelerated through subsidies. The public sector can serve as an example and begin using renewable fuels in running their fleets of vehicles, including public transport. At present, the numbers of low-emission and zero-emission vehicles in use are very small. When fleets of vehicle are renewed, we need to move over to using hybrid cars and electric cars and other low-emission vehicles far more is happening at present. In the long term, the use of hybrid cars and electric cars and the use of new-generation biofuels must be supported with the ultimate objective of getting altogether rid of vehicles using fossil fuels.

3.4 URBAN STRUCTURE AND PLANNING

Urban structure has a significant impact on traffic as well as on the need for energy and on energy consumption. Urban planning defines to a high degree the volume of and need for traffic. Energy-conserving aspects not currently included in this category of planning. Indeed, energy and traffic considerations should be embodied in planning and assessment procedures.

Urban planning can be used in directing urban structure to be more close-knit, and then also the possibilities for implementing public transport improve. This in turn enables optimisation of heating systems so that the different heating forms will be used in ways that most appropriate in term of overall economics and ecology. The same also holds true for the rest of municipal engineering, e.g. supply of electricity and water.

3.5 BUILDING AND LIVING

The consumption of energy accounted for by buildings, i.e. the heating of buildings and the electrical power consumed in the buildings in other ways, the manufacturing of building materials, and building itself account for approx. 40% of the final energy consumption in Finland and approx. 30% of Finland's carbon dioxide emissions. [5]

Regarding the role of building in energy conservation, it should be borne in mind that the renewing rate of the stock of buildings is very slow, being only about 1% per year. Thus, only 40% of the buildings will be new (built in 2009 or later) in 2050.

The energy consumption of buildings is linked to their time of building. For example, the energy consumption of buildings in 2003 was a third less than that of 1960's buildings. The energy consumption of modern low-energy buildings is less than half of that of houses built before the 1980's. Indeed, the biggest emissions-reduction potential related to building can be attained through basic renovation and energy-efficiency modification. The associated regulations and norms are being reformed at the present. The instructions directed at the building industry and developers, and the associated training need further implementation in order to have serious building errors eliminated.

As part of the endeavour to reduce the emissions of the building sector, targets need to be set for reducing the CO2 emissions caused in the manufacturing of building products and of building itself, and assessments of the environmental effects of building and building products must be performed already at the planning stage.

Building regulations and the associated calculations need to be developed to facilitate the entry to the marketplace of innovative solutions. Experimental building should be provided with better opportunities. Building in general is heavily regulated and it is difficult to obtain permits for experimental building. Establishing the functionality of new building norms may take dozens of years before possible problems stemming from the new technologies and materials applied become apparent.

3.5.1 HEATING

The aim is for the nominal consumption of heating energy to decrease. However, the volume of building will increase simultaneously with an increase in living space and the number of households, and in the building of commercial centres and recreational centres and other similar facilities for free-time activities. This means that the total consumption of heating energy may even increase from what it is at the present.

The nominal consumption of heating energy used in heating the building stock has dropped markedly from what is was in the 1960s. The heating energy needed in the 1960s for maintaining a good indoors temperature was 160 – 200 kWh/m2 , in the 1980s it was 100 – 140 kWh/m2 , and in buildings built since 2003, it had fallen to 80 – 100 kWh/m2. With ecologically designed houses, the estimate presented by VTT is that 40 – 60 kWh/m2 is possible. VTT estimates the building stock to increase from 496 million m2 in 2007 to 536 million m2 by 2020, and 559 million m2 by 2050. [3]

The need for heating energy can be reduced by introducing stricter energy-conservation regulations for application in new buildings. However, the authorities need to ensure that the norms introduced are fully thought out, workable, and reliable. Wider application of low-energy solutions can also result in energy conservation.

As regards the existing building stock, attention must be paid to implementing large-scale upgrading of the heating and ventilation systems, and to making use of lost heat in connection with basic renovation. This is also the time to look into the need for control of heating and ventilation. Economic incentives are needed to speed up development.

Heating systems based on circulating water enable adopting of almost any kind of energy source, and such systems should, indeed, be favoured. Where possible, floor heating based on circulating water should be favoured as one of its advantages compared to water-based radiators heating is its lower surface temperature. Another of its advantages is its more evenly distributed heat. The technical and economic possibilities to convert electricity-heated houses to use district heating or some other form of heating should also be looked into.

The heating of houses can be arranged to be controlled by a smart system and thereby achieve significant savings in the consumption of heating energy, particularly during shorter absences. Yet another point to note is that all rooms need not be equally heated.

3.5.1.1 HEATING FORMS

District heating should be used as much possible in heating. Where district heating is not a feasible option, the use of heat pumps should be promoted. The popularity of ground-source heat pumps is on the rise. Especially air heat pumps are being installed to replace or supplement electric heating of existing buildings. Regulations hindering the wider use of ground-based heat should be discarded to enable the greater exploiting of this energy source also on public lands and in connection with extensive building projects.

Suomen Lämpöpumppuyhdistys (Finnish Heat Pump Association) estimates that by 2020 there will be over 1,000,000 heat pumps installed in Finland, while at the moment there are 220,000. The annual installation numbers of ground-based heat pumps is expected to increase from 7,200 in 2008 to approx. 20,000 by 2020. The annual sales of air heat pumps is predicted to saturate at approx. 80,000 units. The number of air-water heat pumps will undergo a powerful increase in the near future. The number of exhaust-air heat pumps will increase less powerfully, but the increase in these pump types installed in larger buildings will be more pronounced.

By the year 2020, heat pumps may be taking in 8- 10 TWh (29 – 36 PJ) of primary energy from nature, i.e. the amount by which heat pumps can be used to substitute for other forms of energy generation.

The greatest potential that still remains untapped is that of large plants, and many of these are expected to be set up during the coming years. The same applies to heat pumps for large buildings; their number will also undergo a powerful increase during the following years.

Pellet-based heating will increase a little in the future. This heating system takes up a lot of space mainly because of the space needed for the storage of the pellets. Compared to other heating forms, it is also more laborious. These two factors set challenges of their own for the wider usage of pellet-based heating.

3.5.2 CONSUMPTION OF ELECTRICITY

The consumption of electricity by households has increased continuously. During the years 2000 – 2005, consumption increased by about 14%, and in 2005 it exceeded 10 TWh (36 PJ). A significant part of the growth is caused by increased consumption coming from single-family houses. As homes become larger and as their level of equipping improves, consumption also increases. The electricity consumption of refrigeration devices is on the decrease, but the consumption coming from consumer electronics equipment has undergone a powerful increase. [3]

One readily implementable and inexpensive conservation method is promoting people's awareness. Advisory services and changing people's attitudes is a way of changing people's consumer habits in the direction of energy conservation. Also, by getting real-time consumption data , we can monitor consumption, and this in itself has been found to have a consumption-reducing influence. State-of-the-art technology enables the consumption data of individual devices to be readily visible.

Functional smartness can be easily included in electrical apparatuses. "Dynamic Demand" is a function that temporarily switches a device off if the network becomes overloaded and the current frequency falls. The functioning of many devices (e.g. refrigeration and ventilation equipment) can be stopped without a worry for a short while, e.g. for 15 minutes. Smart control of electrical apparatuses can be used in other ways, too; e.g. by having stand-by mode switching on only after the owner is inside the house. The control of lighting can be arranged so that the lights go out automatically when a room is vacated.

As regards second homes (where people spend their free time), smart actuators and networks can be used to minimise unnecessary heating of the building when no-one is there and to focus the use of energy to essential parts and specific points in time.

3.5.2.1 DEMAND ELASTICITY AND PRICING POLICY

Demand elasticity is important from the point of view of consumers. During periods of peak loads, consumers would have the option of demonstrating reducing their consumption and this would yield economic benefits. Real-time and remote reading of consumption enables discounts for frugal consumers.

Also, pricing policy is of significance for consumption and in levelling consumption peaks. For example, night-time electricity during the summer could be significantly less costly than day-time electricity in mid-winter. The measuring technology mentioned in the previous chapter provides the basis for efficient utilisation of pricing control.

3.6 INDUSTRIES

About half of the electricity consumption in Finland is consumed by the industrial sector, and of this electric motors, drives, pumping, fans, and air compression account for about 75%. Consequently, it is to be expected that there is a lot of potential for conserving energy in running these devices. Other targets of improvement are insulators, fixing of leaks in buildings and equipment, better settings, material recycling, and improved energy management.

Great expectations have been set on the energy efficiency of processes and its improvement. On the other hand, consensus has not been achieved as to how efficiency or reduction in consumption should be measured. If efficiency is to be measured, there has to be a readiness at production plants for it. In order that efficiency might be measured, we need more detailed data on processes and partial processes. We need to launch actions aimed at the improvement of readiness as this kind of work proceeds slowly.

When considering the matter of potential energy conservation, three quite different levels must be distinguished: theoretical potential, technical potential, and economically-feasible potential.

Theoretical potential indicates the theoretical maximum level of energy conservation. Here, for example, the availability or the price of the technology are not limiting factors. Technical potential refers to that level for which there exists commercially available technology. Economically-feasible potential is the level at which the investments and measures required by energy conservation are feasible. It is hard to believe that companies would investing in solutions that are not economically feasible. This is why we need to focus primarily on economically-feasible potentials also when discussing the matter.

In regard to improvement of process efficiency, there has been a lot of talk also about the share of frequency converters and electric drives in the endeavour to reduce the consumption of electricity.

European studies have demonstrated that the energy-conservation potential of frequency converters could be as great as TWh (29 PJ). However, according to a recent study by VTT, the feasible total energy-conservation potential of Finland's entire energy-intensive industrial sector, achievable using high-efficiency electric motors and frequency converters, amounted to just 830 GWh (3 PJ). Of course, this potential has to be exploited, but greater energy conservation can be achieved through the correct rating and choice of equipment. [6]

Energy efficiency is important from the point of view of both effectiveness and competitiveness, reliability of supply of energy, and mitigation of environmental impacts. However, there is no justification for setting specific quantitative objectives for individual energy forms, products or processes because these can lead to partial optimisation. Only companies themselves have sufficient knowledge about their own products and processes for them to be developed. Indeed, as a means of improving functions, we should primarily promote the use of means encouraging the adopting of spontaneity. The objective must be to improve the use of the energy overall.

Another problem encountered by the industrial sector is that there have been significant staff cuts and functions have been outsourced. Thus, organisations no longer necessarily have people sufficiently familiar with the processes to be able to identify possible development needs.

3.7 EMISSION TRENDS

The energy sector is the most significant source of emissions, and the solutions implemented in this sector thus have the biggest impact on future emissions. The following table shows the trends in emissions caused by the use of fuels in Finland from 2000 to 2050 when applying the recommendations and default values related to changes in energy generation as presented in this programme. The emissions from use of various fuels will decrease by 73% by the year 2050 from their 2007 level, and by 69% from the 2000 level.

Year	2000	2007	2015	2020	2030	2050
CO2 emissions, millions of tonnes	52,9	61,8	57,2	48,3	24,5	16,6

Table 1. Estimated emission trends caused by the use of fuels in Finland during the period 2000 – 2050.

In addition to the above, other significant sources of greenhouse gas emission include industrial processes, agriculture, and waste, their share of emissions being 19%. The emissions of these sectors are not examined more closely in this connection. Even if emissions external to the energy sector were to remain unchanged, Finland's total emissions would diminish by approx. 60% by the year 2050 from their level in 2007, and by more than 50% from their level in 2000, which also complies with the IPCC objective. In fact, emissions in these sectors, too, will decrease. For example, the emissions caused by waste decrease as a result of significantly improved sorting and recycling, and of waste being used to generate energy. Figure 5 shows the total consumption of energy and the trend in carbon dioxide emissions released by the energy sector during the years 1990 – 2007, and the estimated the trends up to 2050.

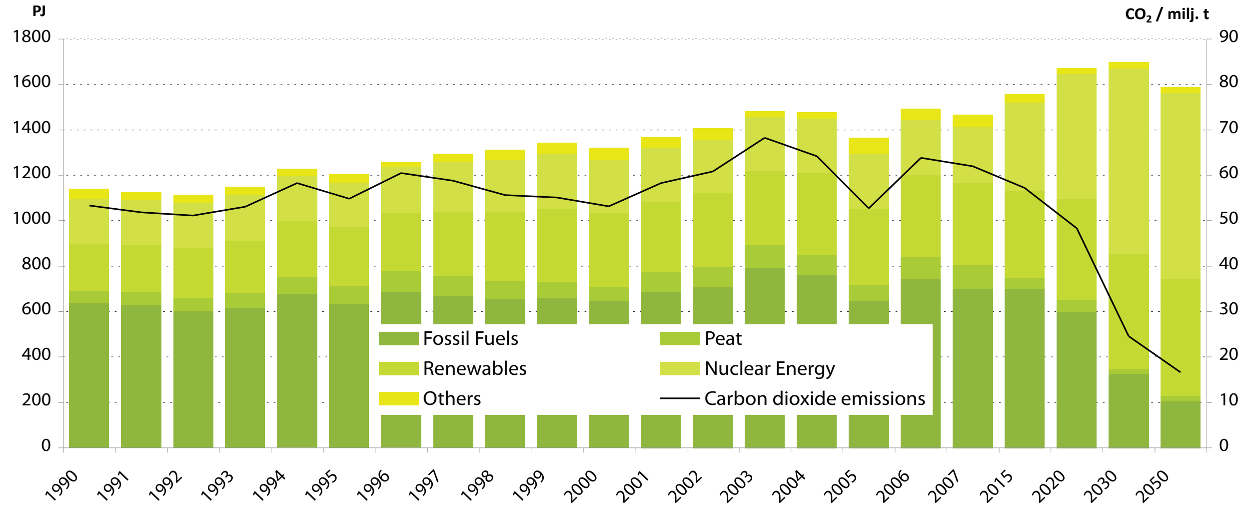

Figure 5. Estimated trends in the total consumption of energy and the energy sector's carbon dioxide emissions in Finland during the period 1990 – 2050.

4 GENERAL PUBLIC MEANS OF STEERING

The key technologies for reducing emissions exist, but a significant issue is that of how to introduce them and to put them into general use. Finnish expertise in energy and environmental technology and in the associated IT and communication technology are of leading world standard. There is expertise elsewhere as well, and for Finland to be able to maintain its position, we need to make increasing investment in promoting these fields.

4.1 RESEARCH AND DEVELOPMENT

The technology of tomorrow is based on research done today. Inputs into research and development, and improving the efficiency of energy use have the effect of significantly reducing the costs of achieving cuts in emissions. Indeed, increasing amounts of funding must be directed at developing energy technology and environmental technology, and improvement of energy efficiency. The global markets for technologies using renewable energy sources, emission-free and low-emission technologies will expand and open up significant export opportunities for Finnish technology and engineering expertise. Research must strive towards achieving international cooperation in order that the results and Finnish expertise might come to enjoy global renown.

The Finnish government has set as its goal the doubling of investments in R&D in the energy sector from its current 60 million euros to 120 million euros by the year 2020. The amount required is probably more than this. Furthermore, added attention must be focused on the consequences for the energy sector of other technological and innovation activity, and on the appropriate management of the whole made up of these.

The degree of utilisation of smart networks in energy technology must be raised and made into Finland's special strength. This provides opportunities for benefiting from our powerful ICT expertise. Remote measurements at the commissioning stage provide a good starting point in this area. There are considerable possibilities for expansion in the generation and distribution of energy as well as in its use. With this in mind, we need to implement a focused technology programme dedicated to exploiting smart network technologies in the generation, distribution, and end use of energy (with the involvement of Tekes/Sitra).

Innovation policy and energy policy need to be interconnected more closely. The innovation system's instruments can be made more efficient use of in producing new solutions to the problems encountered in energy policy. Long-term R&D is a precondition for the development of new energy-efficient solutions. Finland's solid R&D infrastructure is a national strength factor and it provides a base for seeking new opportunities. A technology programme focused on energy solutions in renovation of building is also needed (with the involvement of the Ministry of Employment and the Economy plus Tekes).

4.2 EXPERTISE, EDUCATION AND TRAINING

Technology and persons with technical tertiary training are in a pivotal role in repelling climate change and in helping mankind to adapt to the impacts. Expertise and education and training are in central positions ensuring that skilled people are involved in technological development also in the future. The quality of education and training and of teaching materials must be attended to, and investments are needed in education and training and research in order that we might reach the short-term and long-term objectives. Together with the foremost stakeholder groups representing tertiary education and training in technology, TEK and UIL have formed a group calling itself Tekniikan yhteistyöryhmä (Cooperation Group in Technology). To date, the Group has formulated a strategy for the sector and actions programmes profiling the various universities of technology, for developing the quality of tuition, and for promoting sustainable development in university-level education and training in technology. [7]

Sustainable development and energy-efficiency know-how must be included in educational and training programmes as permeating themes and connected to the core know-how in each field of specialisation. In addition to basic education and training, further education and training must also be developed so that the level of competence can be retained and updated to meet the needs that arise.

The demand for expertise, especially in the energy field, has increased strongly. We need to ensure that there will be enough experts in this field in future years as well. However, energy efficiency must be part of all development of technology, and so energy-efficiency know-how must be part of the expertise possessed by all engineers in the years to come.

Strategy work specific to the climate and energy cluster must be launched. The objective is for Finland to become a "climate country" through expertise and application, and a significant exporter and developer of energy technology, environmental technology, and climate technology.

4.3 ENERGY APPROPRIATION IN THE BUDGET

The temporary additional budgetary appropriations of the Ministry of Employment and the Economy should be made permanent. And the present levels of these appropriations must be retained. The proposed investments in the energy sector are also partly investments in infrastructure, equipment, development of technology, and promotion of know-how. This would also ensure the retention of activeness in the engineering industry through energy-related investments.

4.4 MEASURES AIMED AT PROMOTION OF ENERGY EFFICIENCY

Energy efficiency to be raised throughout the economy to the position of a selection criterion when carrying out public procurements. The public sector to assume the role of a pioneer in the improvement of energy efficiency.

Actors in the public sector to be obligated to carry out all those energy-efficiency measures where the pay-off period is below a certain number of years, e.g. 5 years. Correspondingly, actors in the private sector to be offered economic incentives in similar cases, e.g. opportunities for accelerated depreciation or tax concessions.

Tools, methods, and reporting models to be developed with public sector funding for the assessment of the energy-efficiency of logistics systems.

Improved consideration of energy efficiency to be applied in the planning of land use. The development needs of land-use and building legislation to be examined with this as the basic premise.

Bringing energy-efficiency and energy-conservation goals down to earth should be made part of the national architectural policy and regional and local programmes.

At the moment, there is very little attention attached to energy efficiency in the process of granting environmental permits. One precondition to the awarding of environmental permits should be the adequate heeding of energy efficiency.

The awareness of the general public of their consumption of energy is to be promoted and facilitated. Ecological profiles including energy efficiency to be included with consumer products and services. Commensurable, fair, and incentive-oriented methods should also be developed for the voluntary tracking of in-house and individual energy consumption and for determining personal carbon footprints.

As a means of maximising global efficiency, energy-efficient technology should be made commercially and widely available as soon possible. Demo projects and focused joint-procurement bidding competition are needed.

5 SUMMARY AND CENTRAL CONCLUSIONS

Emissions of greenhouse gases must be limited, and this requires speedy actions. Calculations indicate that the objectives set in Finland for climate emissions can be carried out and that the technology means for doing so exist. The issues at stake are that of creating an operating environment enabling these actions and of the resolute realisation of the said actions. Despite emissions being delimited, climate warming will continue to proceed for a long time, and alongside the actions taken to reduce emissions, we also need to prepare for the changes caused by the warming of the climate. There is no single solution; we need to apply all means available to us.

We need to reduce energy consumption in all sectors of human activity. The industrial sector is engaged in developing calculation methods for the energy balances of processes, in improving the recovery of otherwise lost heat energy, and in developing planning and operating know-how. Attachment 1 presents a collection of actions collected via a questionnaire conducted among the memberships of TEK and UIL and showing how individuals can play a part in conserving energy and thereby reduce emissions.

As regards households, more information is being made available to people, e.g. by improving the real-time availability of consumption data. Moreover, smart network and regulating units are being developed and put to use, e.g. Dynamic Demand functions.

Building regulations are being developed in the building sector. The aim in heating is to promote the use of emission-free heating forms, e.g. use of heat pumps, through tax incentives or regulations. A focused technology programme of energy solutions for renovation is also needed to improve the energy efficiency of buildings.

Public transport is being developed to be more attractive to commuters. Especially in population centres, the possibilities of automated rail traffic are being made use of. Taxation-related means are being applied to encourage motorists to shift over to low-emission vehicles. The stock of vehicles used by the public sector is being gradually renewed with vehicles using renewable fuels or with vehicles based on hybrid or electric technology. Traffic volumes are also being reduced by means of planning. Planning is implemented with energy and climate issues being clearly heeded in other ways, too, to serve as the basis for decision criteria, and energy and climate analyses are integrated in the YVA (environmental effects) procedure.

Minimising the use of fossil fuels and their replacement with emission-free energy generation means are of crucial importance. In accordance with the estimate presented in this assessment, the use of fossil fuels in Finland should be reduced to less than one third of the present level by the year 2050. The most significant increase is in the share of nuclear power. Also, the use of the bio-energy will increase and reach its peak in 2030, and then stay at that level thereafter. In addition to the above, the generation of wind power and hydro-power and the use of waste in generating energy, and the use of heat pumps will increase. Net imports of electricity will gradually decrease and cease altogether by the year 2020.

The calculation is based on nuclear power capacity being further added to after Olkiluoto 3 with another unit by the year 2020, and by further two units by the year 2030. On the other hand, Loviisa 1 and 2 will be decommissioned by that time.

The generation of hydro-power will be increased by updating the existing generation equipment and by utilising the potential of the already harnessed water systems.

Wind power capacity will be expanded from the present approx. 100 MW to 1500 MW by the year 2020 and to 4000 MW by the year 2050.

In addition to energy generation, consumer habits, ways of using energy, and improvement of energy efficiency are of decisive importance. The basic precondition for this development is, however, to achieve an acceptable and equal international emissions trade and sharing of the burden. Being able to keep to the favourable development in Finland requires both the development of positive market-based incentives as well as sensible use of mandatory regulation-based steering. Both carrots and sticks are needed, wisely used. Other essential requirements for reaching the objective are large investments into research and development, and into education.

Education is in a key position in order that skilled people are available to develop technology also in the future. Expertise in sustainable development must be included in all education and training programmes in the field of technology, and this must be linked to core know-how. At the core of expertise in sustainable development there are the following: material and energy flow and energy efficiency, the ability and readiness to apply critical thinking, and system and lifespan thinking. In order that the objectives might be reached, it is necessary to clarify the foremost issues related to sustainable development and do so field-specifically and include them in educational programmes. Investments must be made in the quality of education and in the development of educational methods and learning environments.

The connection between innovation and energy policy will be made firmer through means such as a focused technology programme for utilising intelligent networks in the generation, distribution, and use of energy. The public energy sector's R&D inputs should be increased to 150 million euros by the year 2020.

The role of technological development is of decisive importance in the production and distribution of energy as well as in its end use. Technology also creates possibilities for steering and influencing end users and consumers. For the objectives to be achieved, these possibilities must be fully utilised.

Environmental technology and energy technology, along with improving Finland's national emissions situation, can be developed into a considerably larger field of export than it is at present. This also means that fields whose significance in the Finnish system is due to remain minor – e.g. solar energy and capturing of carbon dioxide – may evolve and attain greater domestic importance. Solving the global climate problem presupposes the creation of efficient and utilisable concepts also in developing countries.

Achieving the outlined final result requires determined efforts and a broad-in-scope approach. The challenge is immense, but the assessment made shows that the solutions can be found.

6 SOURCES

[1] Energiatilasto – Vuosikirja [Annual Energy Statistics] 2008, Tilastokeskus / Statistics Finland

[2] Kasvihuonekaasujen inventaario [Greenhouse Gas Emissions Inventory], Tilastokeskus / / Statistics Finland

[3] Teknologiapolut 2050 – Teknologian mahdollisuudet kasvihuonekaasupäästöjen syvien rajoittamistavoitteiden saavuttamiseksi Suomessa [Technology Paths 2050 – Technological Possibilities for Achieving Reduction Objectives Set on Emissions of Greenhouse Gases], VTT / Technical Research Centre of Finland

[4] Teknologiapolut 2050 – Skenaariotarkastelu kasvihuonekaasupäästöjen syvien rajoittamistavoitteiden saavuttamiseksi Suomessa [Technology Paths 2050 – Assessment of Scenarios for Achieving Reduction Objectives Set on Emissions of Greenhouse Gases], VTT / Technical Research Centre of Finland

[5] Energiatehokkuustoimikunnan mietintö: Ehdotus energiansäästön ja energiatehokkuuden toimenpiteiksi [Energy Efficiency Committee Report: Proposal for Actions Aimed at Energy Efficiency and Conservation of Energy], Työ- ja elinkeinoministeriö / Ministry of Employment and the Economy

[6] Sähkönsäästöpotentiaali energiatehokkailla sähkömoottorikäytöillä Suomen energiavaltaisessa teollisuudessa [Potential for Conserving Electricity When Using Electric Drives in Finland's Energy-Intensive Industries], VTT / Technical Research Centre of Finland

[7] Tekniikan yhteistyöryhmän julkaisut [Publications of the Cooperation Group in Technology], available at: www.tek.fi/yhteistyoryhma

In addition to the aforementioned literature sources, the expertise of several persons has been made use of.

APPENDIX 1: RESULTS OF QUESTIONNAIRE STUDIES CONDUCTED AMONG TEK AND UIL MEMBERSHIP

As background material for the Future Climate project, we collected views on energy and climate matters from among the memberships of TEK and UIL at the end of 2008. The questionnaire was targeted at a randomly selected sample from among the total of 4,000 members of these two unions to reflect the membership as comprehensively as possible. The response rate was approx. 27%, and this can be considered to be a good result and the data collected to be representative of the opinions of TEK and UIL membership on climate and energy issues. The responses given to the questionnaire were also compared with those given in connection with a nationwide study assessing energy attitudes and aimed at the general public. It was conducted by Energiateollisuus ry (Finnish Energy Industries, ET) in 2006. Table 1 shows a summary of the support given to the various forms of generating energy in the TEK-and-UIL questionnaire and in the nationwide study.

The foremost difference in views between the average Finn and Finnish engineer is in the support given to nuclear power: engineers are clearly more in favour of nuclear power. This is no big surprise as already at the beginning of the new millennium more than 70% of TEK's membership favoured expanding of nuclear power generation. Engineers' more positive attitude to nuclear power when compared to that of the average Finn can be explained, in part at least, by the fact that engineers know the technology and its possibilities better than other people.

However, a little surprising perhaps was the result that engineers favoured wind power more than the general population. As regards importing of electrical power and the use of peat in generating electricity, the engineers were, however, more sceptical than others.

The majority of engineers also favoured expanding of solar power and wind power, but they did not see them as solutions for satisfying the demand for electricity. Local production close to consumption points was considered to be the best and most efficient way of utilising these energy sources, e.g. house-specific wind generators and solar cells.

Comparison data on solar energy and energy recovery from waste was not available for the nationwide energy-attitudes study.

	Engineers 2008	All Finns 2006
Energy recovery from waste	96 %	
Solar Energy	93 %	
Wind power	92 %	87 %
Wood-based and other bioenergy	81 %	83 %
Nuclear power	77 %	43 %
Hydroelectricity	65 %	67 %
Peat	36 %	43 %
Natural gas	31 %	33 %
Importing of electricity	5 %	11 %
Coal	2 %	5 %
Oil	1 %	3 %

Table 1. Proportionate support given to expanding the use of various energy sources in the TEK and UIL questionnaire study of 2008 and in the nationwide energy-attitudes study of 2006.

ENGINEERS READY TO TAKE ACTION

Engineers' and the general population's views on climate change are very similar. To take an example: Regarding the claim *"The exceptional weather conditions of the recent years are indications of climate change"* , 73% of engineers were fully or partly in agreement, and the corresponding figure for the population as a whole was 74%.

Regarding the claim *"In order to help reduce the environmental harm and risks resulting from energy generation, I am prepared to personally accept a lower standard of living"*, 65% of engineers were fully or partly in agreement, but the corresponding figure for the population as a whole was 56%. In other words, there are engineers who are prepared to make "eco-self-sacrifices", and even more than in the general population.

Most support of all as regards personal measures was directed at conserving energy in general and especially of conserving heating energy. Many engineers were prepared to drop their room temperature as a means of cutting energy consumption. Other such actions mentioned were switching over to a less polluting heating form, and many planned to install a heat pump, for example. In order to conserve electricity, some respondents stated that they were prepared to replace incandescent lamps with energy-conserving lamps, to switch off their electrically operated devices altogether (not leave them in stand-by state), and to pay attention to the energy efficiency of domestic appliances. At workplaces, too, major energy conservation can be achieved; e.g. by turning off computers and copying machines and lights at the end of the day.

There was also willingness to do more sorting and recycling of waste, and to reduce water consumption. The respondents also favoured actions such as apartment-specific water meters, which would encourage people to monitor their own consumption if paying for the water were to be based on actual consumption.

Conservation possibilities were also noted in regard to travel and commuting. Using one's own car less or getting rid of it altogether were by far most popular solutions. However, before switching over to using public transport, people expressed the view that it would have to be inexpensive and properly functional as regards both routes and timetables.

Also, many of the ones not prepared to or not able to give up owning a car, have either replaced or are planning to replace their car for a less-polluting model. People have already now cut back or are now cutting back on travelling abroad. Especially teleworking and video conferencing were deemed to be good methods for reducing work-related travel.

Ideas put forward in the responses to the questionnaire whereby individuals can conserve energy and thus reduce emissions are presented in following pages. They are all familiar ones, but for some reason they have not found wider usage. Indeed, the main question is how can we get people to put into practice the conservation measures that have been recognised and that can easily be implemented. Some progress in this can be achieved by impacting on people's attitudes. This is a topic also for politicians to consider as they could provide incentives for practising energy-conserving and pro-environmental action by passing relevant legislation.

ACTIONS AVAILABLE TO INDIVIDUALS IN THE ENDEAVOUR TO CONSERVE ENERGY AND REDUCE EMISSIONS

The following presentation has been put together using the responses obtained from TEK and UIL memberships in response to a questionnaire on means for conserving energy and reducing emissions. The actions listed have been classified under various themes: travel, living, work, free-time, and consumer habits.

Living

- Conserving heating energy, using low-emission energy
- Reducing indoor temperature, including improved regulation of temperature
- More energy-efficient form of heating
- Soil-based heat
- Improvement of insulation in house
- Air-based heat pump to supplement heating system
- Wood-based heating
- Green electricity
- Wind
- Sun

- Adding to energy self-sufficient, house-specific small-scale wind-powered power plant
- Overall reduction in consumption of electricity/heat
- Washing laundry etc. at a time when consumption is low
- Replacing electrically-heated sauna stove with a wood-fired sauna stove
- Reducing use of sauna
- Reducing use of entertainment electronics
- Reducing use of lighting, switching off lights when not needed
- Switching off home appliances for the night / when not used (switching off stand-by mode)
- Energy-efficient electrical equipment, reducing number of electrical equipment
- Energy-saving lamps, LEDs
- Refrigeration equipment
- Entertainment electronics
- Are all electrical devices in the home necessary?
- Improving/increasing recycling/sorting, less waste
- Reducing use of water
- Washing only when machine is full
- Reducing use of shower
- Use of water-conserving programmes
- Collecting rainwater for watering garden
- Moving into a smaller home

Travel

- Reducing use of own car, getting rid of own car
- Increased use of public transport
  - If possible
  - Must be functioning and inexpensive
- Getting a low-emission/low-consumption/ smaller vehicle
- Reducing amount of travelling/using low-emission forms of transport
- Flying less
- Less holiday trips
- Tax-per-mile when flying
- Move over to virtual travelling
- More cycling
- More walking
- Reducing travel, combining several purposes in travel

Work

- Conserving electricity/changing habits regarding use of electricity at workplace, e.g. switching off lights
- Teleworking
- Video conferences
- Favouring environmentally-friendly alternatives at work/workplace
- Reduction of temperature at workplace

Consumer habits

- Reducing unnecessary consumption, reducing use of disposable products
- More ecological consumer choices
- Products to show data on energy consumption and carbon footprint
- Favouring locally produced products and services, including local foods
- No more eating of meat, general reformation of eating habits

Free-time

- Reducing temperature of holiday home, basic temperature not to be on all the time
- Cutting back on holiday home use, no more holiday home/second home
- Replacing of insulation at holiday home + heat pump installation
- Heat pump for holiday home
- Only solar electricity to be used at holiday home

Other actions

Personal actions

- Taking part in volunteer work
- Supporting of environmental organisations
- Advising friends and acquaintances
- Plating of trees

Actions to be taken by society

- Taxation to be used to influence consumer behaviour, energy-consumption related taxes/ environmental taxes
- Earmarked use of additional taxes in a focused and monitored manner
- Limiting private motoring via political and economic incentives or taxes
- Changing vehicle tax to favour low-emission vehicle ownership and use
- Indigenous fuels used in traffic to be made tax-free
- Development and supporting of mass transportation also in smaller towns

Other actions

- Packaging of products to be reduced, more sensible packaging
- Street lights to be switched off for the night
- Less use of advertising lights
- Less use of advertising mail

APPENDIX 2: EXPERTS INTERVIEWED DURING THE ASSESSMENT

Among the persons, who have contributed to the drawing up of this programme, are the following, and they were interviewed at various points in time as experts.

Petri Koivula, Finnish Heat Pump Association
Martti Kätkä, Federation of Technology Industries
Jaakko Ojala, Ministry of the Environment
Pentti Puhakka, Ministry of Employment and the Economy
Ilkka Savolainen, VTT Technical Research Centre of Finland
Lassi Similä, VTT Technical Research Centre of Finland
Risto Tarjanne, Lappeenranta University of Technology
Jarmo Hallikas, TEK's Technology Committee
Timo Härmälä, UIL's Education and Industry and Trade Committee
Antti Juva, TEK's Technology Committee

In addition to the above persons, discussions have also been held with and assistance has been received from numerous persons representing various universities, research institutions, and branches of industry.

The calculations presented in the programme concerning the impacts of the various actions were produced by professor Risto Tarjanne of Lappeenranta University of Technology.

Representatives of both unions have contributed to the processing of the work, and committees and the boards of both unions have submitted comments at various stages of the work. In addition, a seminar open to the membership was arranged in connection with TEK's Spring Conference, and this topic was dealt with there as well.

A significant reduction of greenhouse gas emissions is mandatory for effectively slowing down the climate change currently underway. Rapid actions on both national and global level are required. In order to keep the rise in temperature below 2 ºC it is estimated that greenhouse gas emissions must be reduced by 50 %–85 % by 2050.

As the Finnish contribution to the international Future Climate project the leading engineering associations in Finland, the Finnish Association of Graduate Engineers TEK and the Union of Professional Engineers in Finland, UIL, have drawn up the profession's proposal for a national climate plan, wherein technology-based means for cutting emissions and for slowing down climate change are presented.

To a great extent the necessary technologies for reducing emissions do exist. However, large inputs in research and product development are still needed if we are to develop more efficient means of reducing emissions to the required level.

The international Future Climate project involves using national programmes as the basis for preparing engineering organisations' common recommendations for technology-based means of reducing emissions and slowing down of climate change. These recommendations will also be presented to the UN Climate Change Convention in Copenhagen in December 2009.

THE FINNISH ASSOCIATION OF GRADUATE ENGINEERS TEK

Union of Professional Engineers in Finland

Future Climate Engineering Solutions