TEK & UIL
Engineering Associations’ National Climate Plan for Finland 2011
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1 Introduction 9
1.1 SOME BASIC PREMISES 9

2 The Present Situation 11
2.1 CONDITIONS IN FINLAND 11
2.2 FINLAND’S ENERGY CONSUMPTION 11
2.3 FINLAND’S GREENHOUSE GAS EMISSIONS 11

3 Reduction of Emissions in the Various Sectors 13
3.1 ENERGY CONSUMPTION 13
   3.1.1 CONSUMPTION OF ELECTRICITY 13
   3.1.2 ENERGY CONSUMPTION BY SECTOR 13
   3.1.3 TOTAL CONSUMPTION OF ENERGY 14
3.2 ENERGY GENERATION 15
   3.2.1 NUCLEAR POWER 15
   3.2.2 HYDROELECTRIC POWER 16
   3.2.3 WIND POWER 16
   3.2.4 SOLAR ENERGY 16
   3.2.5 WASTE INTO ENERGY 16
   3.2.6 BIOMASS 17
   3.2.7 COAL 17
   3.2.8 COMBINED HEAT AND POWER GENERATION 17
   3.2.9 CARBON CAPTURE AND STORAGE 18
3.3 TRAFFIC 18
   3.3.1 REDUCING VOLUME OF TRAFFIC 18
   3.3.2 SUBSTITUTES FOR FOSSIL FUELS 18
3.4 URBAN AND COMMUNITY STRUCTURE AND PLANNING 19
3.5 BUILDING AND LIVING 19
   3.5.1 HEATING 20
   3.5.2 CONSUMPTION OF ELECTRICITY 21
3.6 INDUSTRIES 21
3.7 EMISSION TRENDS 22

4 General Public Means of Steering 24
4.1 RESEARCH AND DEVELOPMENT 24
4.2 EXPERTISE AND EDUCATION AND TRAINING 24
4.3 ENERGY APPROPRIATION IN THE BUDGET 25
4.4 MEASURES AIMED AT PROMOTION OF ENERGY EFFICIENCY 25

5 Summary and Central Conclusions 26
PART 2: ASSESSMENTS SPECIFIC TO CERTAIN FIELDS OF INDUSTRY

1 Introduction 34

2 Impacts on climate of wood-based bioeconomy, smart grids, and sustainable urban and community structures 35

3 Wood-based bioeconomy 37
   3.1 SIGNIFICANCE FROM THE VIEWPOINT OF CLIMATE CHANGE 37
   3.2 DESCRIPTION OF FINLAND’S PRESENT SITUATION 38
   3.3 CHANGES IN EXPERTISE NEEDS AND JOB OPPORTUNITIES 39
      3.3.1 DEVELOPMENT WITHIN THE FIELD AND EXPERTISE NEEDS 39
      3.3.2 CHANGES IN EMPLOYMENT OPPORTUNITIES 39

4 Smart grids 42
   4.1 SIGNIFICANCE FROM THE VIEWPOINT OF CLIMATE CHANGE 43
   4.2 DESCRIPTION OF FINLAND’S PRESENT SITUATION 44
   4.3 CHANGES IN EXPERTISE NEEDS AND JOB OPPORTUNITIES 45
      4.3.1 DEVELOPMENT WITHIN THE FIELD AND EXPERTISE NEEDS 45
      4.3.2 CHANGES IN EMPLOYMENT OPPORTUNITIES 47

5 Sustainable urban and community structure 49
   5.1 SIGNIFICANCE FROM THE VIEWPOINT OF CLIMATE CHANGE 50
   5.2 DESCRIPTION OF FINLAND’S PRESENT SITUATION 50
   5.3 CHANGES IN EXPERTISE NEEDS AND JOB OPPORTUNITIES 50

6 Demand for engineers now and in the future in areas of wood-based bioeconomies, smart grids, and sustainable urban and community structures 53
   6.1 ACADEMIC ENGINEERS AND ARCHITECTS 53
   6.2 ENGINEER GRADUATES FROM POLYTECHNICS AND UNIVERSITIES OF APPLIED SCIENCES AND BACHELORS OF SCIENCE IN ARCHITECTURE 55

7 Summary 57

8 Sources 59
ABBREVIATIONS, UNITS AND CONCEPTS

CCS  Carbon Capture and Storage

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

CO₂  Carbon dioxide

IEA  International Energy Agency

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 = 1 000 000 000 MWh = 1 000 000 000 000 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.

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

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

Regulation power Capacity by means of the generation 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 generation capacity is called reserve power.
Climate change is a recognised phenomenon and our single biggest cause for concern. This change can no longer be fully prevented from happening and in addition to mitigating the pace of change we need to prepare and adapt to its probable consequences. All the relevant countries and actors must be involved in this endeavor.

If nothing is done, it is estimated that the mean temperature in Finland will rise 4 – 6°C and average rainfall will increase 15 – 25% by the year 2080. For the negative impacts caused by climate change to remain bearable, the objective is to reach a level where global warming will stop at 2 °C when compared to the pre-industrial era. It is estimated that this will require reducing greenhouse gas emissions by 50% – 85% by the year 2050 when compared to their level in 2000.

The Engineering Associations’ National Climate Plan for Finland has been drawn up as part of the Engineering Associations’ International Future Climate – Engineering Solutions Project. The associations of each participant country have drawn up the profession’s proposal of their country’s national climate plan, wherein national structures are analysed and technology-based means for cutting emissions and for mitigating 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.

This plan targets on methods associated with energy generation and consumption whereby greenhouse gas emissions might be reduced. Moreover, the roles of certain selected fields of industry are examined from the point of view of climate change, and the future development and impacts of these fields are estimated from various viewpoints, including employment. In addition to steps taken to reduce emissions, we need to prepare for the consequences of climate change and to consider means for adapting to them. Indeed, this would be an appropriate theme for the next stage of the International Future Climate Project.

The climate plan’s part dealing with energy generation and consumption and the resultant emissions was drawn up in connection with the first stage of the Future Climate Project in 2008 – 2009. As background material for this, we collected TEK (Academic Engineers and Architects in Finland) and UIL (Union of Professional Engineers in Finland) membership’s views on energy and climate matters at the end of 2008. In addition to those who responded to the questionnaire, the following persons contributed to the drawing up of the plan and they were heard as experts in various connections: Petri Koivula (Finnish Heat Pump Association), Martti Kätkä (The Federation of Finnish 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), Jarmo Hallikas (TEK’s Technology Committee), Timo Härmälä (UIL’s Education and Industry and Trade Committee), Antti Juva (TEK’s Technology Committee), and Risto Tarjanne (LUT – Lappeenranta University of Technology), who also did the computations on the impacts of the actions proposed in the plan on greenhouse gas emissions. In addition to the above persons, discussions were held during the project with several persons representing universities, research institutions, and various industries, and in this way they, too, assisted in the drawing up of the plan. The first part of the plan has been updated using the latest statistical data and a few examples of Finnish know-how on how to reduce the emissions of energy generation and consumption have been inserted at the end.

The information of the first part was updated and the climate plan was expanded to include industry-specific assessments at the second stage of the project. The second part of the Engineering Associations’ National Climate Plan for Finland takes a closer look at three fields – wood-based bioeconomy, smart grids, and sustainable urban and community structures – and at their future trends and changes in know-how needs and employment effects. The second part of the climate plan consists of a condensed presentation of the broader-in-scope background report drawn up by Gaia Consulting Oy as an undertaking commissioned and steered by TEK and UIL. The Gaia staff members who contributed to the writing of the report were Päivi Luoma, Pekka Pokela, Erkka Ryynänen, and Elina Virtanen. In addition to the above writers and the representatives of TEK and UIL, the Future Workshop organised as part of the drawing up of the background report was participated in by the following persons: Timo Ali-Vehmas (Nokia), Timo Härmälä (UIL), Laura Katainen (Parker Hannifin), Martti Kätkä (The Federation of Finnish Technology Industries), Mikael Ohlström (The Confederation of Finnish Industries EK), Arto Puumalainen (Mikkeli Engineers’ Association), Aar-
no Valkeisenmäki (Destia), and Jouni J. Särkijärvi. A host of other experts from various fields were also heard and a wide range of source material was studied when preparing the background report. This work has been dealt with and it has been commented upon at its different stages by the two associations’ elected officials, e.g. committees and boards.

The persons bearing the responsibility within the organisations for the drawing up of the Engineering Associations’ National Climate Plan for Finland were as follows: Heidi Husari, manager, Industrial Policy, (UIL), Pekka Pellinen, head of the unit (TEK), and Martti Kivioja, adviser, Technology and Industrial Policy (TEK), who has borne the responsibility for the planning and co-ordination of the work and functioned as the principal writer of the climate plan.
1 INTRODUCTION

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 Future Climate -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 technologies for reducing emissions exist. However, further and considerable inputs in research and product development are needed to produce new technologies and to make the existing technologies even more competitive. In addition to reducing emissions, we must also make preparation for the consequences of climate change and for adapting to these consequences.

The international project involves using national plans as the basis for preparing Engineering Associations’ common recommendations for technology-based means of reducing emissions and slowing down of climate change. These recommendations will also be presented in Durban, South Africa in December 2011 to the UN Climate Change Convention.

The Future Climate Project’s participants include Engineering Associations from around the world, from Europe as well as Australia, India, Japan, and USA. Finland’s contribution was drawn up in collaboration by Academic Engineers and Architects in Finland TEK and 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 / t\text{CO}_2.

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.

Economic trade cycles also have momentary impacts on the consumption of energy and emissions. This paper does not address the matter of impacts of economic fluctuations in any greater detail.

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 2010, the country’s industries accounted for 47% of the total consumption of electricity in Finland. As recently as in 2007, the corresponding share was 53 percent. This drop is partly explained by the shutting down of a number of production plants in the forest-industries sector, which is a high consumer of energy, and the resultant reduction in the industrial consumption of electricity.

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 reference year selected for the Engineering Associations’ International Future Climate Project launched in 2008 is 2007 on which comprehensive statistical data were available at that time. At that time, the total consumption of energy in Finland was about 1470 petajoules (PJ) according to Statistics Finland. The total consumption of electricity in 2007 was 90.4 terawatt hours (TWh). Figure 1 shows the total consumption of energy and emissions of carbon dioxide in Finland in 1990 – 2007. The latest statistics indicate that the total consumption of energy in Finland in 2009 was approximately 1330 PJ and the consumption of electricity was 81.3 TWh. The drop from the 2007 level is largely explained by the economic recessions; first and foremost, by the contraction in production in the forest-industries and metal industry sectors, which are both major consumers of energy.

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 hydro-electric 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. In 2008–2009, emissions were further reduced, and again mainly as a result of the recession. Figure 2 shows Finland’s greenhouse gas emissions by sector in 2009.\(^2\)

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**Figure 1. Total consumption of energy and the energy sector’s emissions of carbon dioxide in Finland in 1990 – 2009. Source: Statistics Finland**

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**Figure 2. Finland’s greenhouse gas emissions by sector in 2009 (%). 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.

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 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 for 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/m²) 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. 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 – 2000: 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 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. The Finnish Parliament ratified in 2010 the decisions-in-principle for the building of two new nuclear power plants. Of these, TVO’s Olkiluoto 4 power plant is designed to generate 1000–1800 MW of electrical power and Fennovoima’s power plant (to be built either in Simo or Pyhäjoki) is designed to generate 1800 MW. In addition to these, Fortum has plans for a unit rated at 1000–1800 MW to be built in Loviisa.

The assumption in this climate programme’s calculations for electricity generation and emissions is that Olkiluoto 3 will be in operation in 2015, 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 H YDROELECTRIC 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 generation 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, at least for the present, 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, 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 bioethanol, 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 expertise, 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 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 36 PJ to about 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 gasifier to a coal-fired boiler and feed the product gas from the gasifier 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 CARBON CAPTURE AND STORAGE

Some major expectations have been set on the carbon capture and storage (CCS) as a means of reducing emissions. CO$_2$ 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 CO$_2$ in these conditions will not result in significant reduction of emissions. Moreover, Finland lacks suitable storage sites for CO$_2$. Elsewhere in the world, coal will continue to be used for many years to come, and so capturing CO$_2$ is a feasible alternative in the endeavour to reduce emissions. There is good reason for continuing to invest in developing CO$_2$ 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 carpooling 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 and community 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 as increased use of biodiesel and ethanol made from biowaste means that fossil fuels are being replaced and traffic emissions are reduced. In Finland, there is
a lot of generation expertise 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 AND COMMUNITY STRUCTURE AND PLANNING

Urban and community structure has a significant impact on traffic as well as on the need for energy and on energy consumption. Urban and community 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 and community planning can be used in directing urban and community structures 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 2011 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 it 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 546 million m² by 2020, and 559 million m² by 2050.

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 longer 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 400,000. The annual installation numbers of ground-based heat pumps is expected to increase from 8,200 in 2010 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 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 35 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. A significant part of the growth is caused by increased consumption coming from single-family houses. As homes become larger and 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.

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 8 TWh. 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. 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.

<table>
<thead>
<tr>
<th>year</th>
<th>2000</th>
<th>2007</th>
<th>2015</th>
<th>2020</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ emissions, millions of tons</td>
<td>52,9</td>
<td>61,8</td>
<td>57,2</td>
<td>48,3</td>
<td>24,5</td>
<td>16,6</td>
</tr>
</tbody>
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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 – 2009, and the estimated 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 AND 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.

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 spe-
cialisation. 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.

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 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. 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 smart 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 generation 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.
6 SOURCES


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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 – Assessments of Scenarios for Achieving Reduction Objectives Set on Emissions of Greenhouse Gases], VTT / Technical Research Centre of Finland


6 Sähkönsäästöpotentialaali 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.
7 CASES

This chapter presents a few examples of Finnish know-how enabling reductions in emissions in the generation and use of energy.

ENERGY FROM WAVES – AW-ENERGY’S WAVEROLLER

The WaveRoller concept developed by the Finnish company AW-Energy Oy is the world’s first power plant making use of the coastal surge of the sea in energy generation. As the depth of water along the sea coast diminishes, the circular motion of water particles becomes elliptical. Along a certain zone, just before the waves break, the motion is constant horizontal back and forth movement.

The WaveRoller unit is composed of plates attached to the bottom of the sea. The back and forth flow of water causes the plates to move, and their kinetic energy is then converted by pistons, a hydraulic motor, and a generator into electrical energy.

One of the advantages of the WaveRoller is its scalability. More disk elements can be connected together to form a wave-energy park and thus generate more electrical power. There is no upper limit to the number of modules that can be interconnected. The electrical power generated by all of the wave-energy park’s units is conveyed along a single underwater cable to the shore. The WaveRoller concept requires less cabling than regular off-shore power plants, and this feature means significant savings in investments. Also, the associated infrastructure and technology are less costly.

The modular structure also eases the job of maintenance as individual units can be decommissioned for maintenance without having to shut down the entire wave-energy park.

AW-Energy is about to launch a pilot power plant of 300 KW, comprised of three 100 KW units, on the coast of Portugal. A single plate designed for commercial use can generate as much as 1 MW of electricity. The nominal output of a plate depends on the local wave-energy resources, i.e. the nominal output is adapted so that annual generation is maximised. The output level of a single plate varies within the range of 0.3 MW – 1 MW.
WASTE INTO ENERGY BY GASIFYING IT – LAHTI ENERGIA KYVO2

A new back-pressure power plant running on recycled waste is under construction in Lahti, Southern Finland, alongside Lahti Energia Oy’s Kymijärvi power plant. The next-generation gasification power plant due to be completed at the end of 2011 and to go on-stream in April 2012, is an internationally significant investment because it represents entirely new pro-environmental technology and it will significantly reduce the consumption of fossil fuels in Lahti.

The core of Lahti Energia’s new power plant is the CFB (Circulating Fluidised-Bed) gasification process, provided with gas cooling and gas cleaning. The cleaned product gas is burnt in a new gas-burning boiler and the final cleaning of the combustion gases is done using a hose filter installed after the boiler before the flue gases are led into the chimney.

The power plant consists of two gasification lines, whose combined fuel efficiency is 160 MW. The plant will generate 50 MW of electrical power and 90 MW of district heating energy. The new plant will be built next to the existing power plant on the present Kymijärvi power plant site.

The technology embodied in the new power plant has been developed in Finland employing Finnish expertise. The entire waste gasification process, gasification boiler and the scrubbing of the flue gases plus the auxiliary equipment and the power plant’s automation system will be delivered by Metso. The steam turbine and the generator will be delivered by Siemens. The fuel reception will be delivered by BMH, and the pipework, HEVAC package, building and process electrification will be delivered by YIT.

The new power plant will use 250 000 tons of waste-based REF fuel per year. The Päijät-Häme Region is Finland’s forerunner in waste recycling and the people there know how to collect energy waste fit for combustion. Landfills and old-fashioned mass combustion technology are relied upon more elsewhere in Finland. Using Lahti Energia’s way of gasifying waste, the yield of electrical energy can be increased manifold when compared to mass burning.

Lahti Energia is the world’s leading waste gasifier already now. Beginning in 1998, some 1.5 million tons of wood-based fuels and waste sorted at the point of origin have been gasified in the old Kymijärvi power plant, and this amount has replaced 700 000 tons of coal. When the new power plant goes on-stream, the consumption of coal in Lahti will be reduced significantly even more.
Kabus Oy is a manufacturer of buses, and the basic idea underlying the company’s hybrid bus is the recovery of braking energy and then using it during acceleration. Conventional buses are slowed down by means of a hydraulic decelerator and pneumatically-operated wheel brakes, which convert kinetic energy into thermal energy. With the hybrid system, the vehicle can be slowed down with the help of an electric motor so that the electric motor then acts like a generator producing electricity.

The electrical power is then stored into capacitors, which are admirably suited for short-term storage of electricity because capacitors can endure rapid charging and discharging better than batteries. Capacitors are also lighter than conventional batteries. Capacitors are used during acceleration when all of the electrical energy recovered in braking is returned to the vehicle as kinetic energy.

The electric motor assists during acceleration when the driver pushes the accelerator pedal. The same electric motor serves functions as a generator when the brake pedal is pressed down which is when the capacitors become charged. With fully-charged capacitors, the vehicle can be accelerated to speeds in excess of 50 km/h and driven to the next bus-stop and even beyond it. The savings are created during acceleration because by operating the electric motor the load imposed on the diesel engine is far less when leaving a bus-stop, and so less fuel is consumed. The diesel engine starts pulling when the electric energy has been exhausted.

Kabus‘ hybrid car is a parallel hybrid, i.e. the electric motor and the diesel engine function side by side. Another other common hybrid type is the series hybrid in which the diesel engine is not mechanically connected to the driving wheels; it is used merely to run the generator. The parallel hybrid is better suited for use in small towns, while in the big cities the series hybrid results in bigger savings; the choice depends on the driving speeds and on the frequency (number) of accelerations and breakings. Outside urban areas, the hybrid technique does not really save fuel because then there is far less braking and thus braking energy cannot be recovered.

Kabus’ hybrid bus has achieved fuel consumption savings of about 30%. The reduction in fuel consumption also reduces carbon dioxide emissions and particulate emissions.
Engineering Associations’
National Climate Plan for Finland 2011, Part 2:
Assessments specific to certain fields of industry
1 INTRODUCTION

This Engineering Associations’ National Climate Plan presents analysis in greater detail of three fields of industry that came to the fore in connection with the Climate Programme published by TEK and UIL in 2009: wood-based bioeconomy, smart grids, and sustainable urban and community structures. The assessment focuses on the future trends of these fields and to the changes in engineers’ expertise needs and employment opportunities. All fields of industry will be subject to significant global developments during the next few years, which in turn will bring about changes in society, in the earnings logic of companies, and in job opportunities. Development has significant impacts also on the mitigation of climate change and how we can adapt to it. A view of development believed to be probable is presented here.

The information and results described in this part are based on a comprehensive review of domestic studies and background reports, on TEK’s and UIL’s own studies and statistics, expert views and on the Future Workshop implemented at beginning of 2011 with the aim of identifying changes in know-how needs and employment opportunities.
2  IMPACTS ON CLIMATE OF WOOD-BASED BIOECONOMY, SMART GRIDS, AND SUSTAINABLE URBAN AND COMMUNITY STRUCTURES

The International Energy Agency (IEA) has estimated the potential of various technologies in globally reducing CO₂ emissions (Fig. 2.1). Clearly the greatest potential is connected to energy efficiency in the use of fuels and electrical power. The efficiency of energy generation and replacing fuels with other fuels, and renewable energy sources also form a significant part of the potential. Significant possibilities are also seen in the global recovery and storage of carbon dioxide, although numerous uncertainty factors are also connected to it.

![Figure 2.1. The possibilities of using various technologies in reducing of CO₂ emissions globally.](Image)

Source: International Energy Agency

The fields of industry assessed here – wood-based bioeconomy, smart grids, and sustainable urban and community structure – constitute significant potential for reducing emissions of greenhouse gases in Finland (Fig. 2.2).

The most obvious and direct reduction potential of wood-based bioeconomy is connected to the increase in the use of the bioenergy. The Engineers’ Associations’ Climate Plan estimates this bioenergy increase potential to be 50 PJ by 2020 and 100 PJ by 2050. The emissions reduction potential corresponds to these is approx. 5 Mt in 2020 and 10 Mt in 2050. Thus the share of bioenergy of the total consumption of the primary energy would be 21 percent in 2020 and 25 percent in 2050. In 2007, the share of the bioenergy was 20 percent. The growth of the wood-based bioeconomy will also include possible carbon sink benefits as emissions-intensive materials and raw materials are replaced by wood alternatives. On the other hand, the increase in the use of the forest-based energy will cause changes in carbon balance of forests. Depending on the technology to be used, the use of wood in generating energy will also increase particulate emissions.

The emissions reduction potential enabled by intelligent electrical power grids in Finland is estimated to amount to 1.5–4 Mt CO₂ by the year 2020; this corresponds to 2–5 percent of Finland’s current total emissions. Smart grids provide the necessary preconditions also for distributed power generation, enabling the utilisation of local renewable energy sources. The potential of smart grids for enabling savings has internationally been estimated to be in the region of 5–9 percent. Significant savings can be achieved especially in the developing countries by reducing wastage and leakage in
the transfer of energy.

The energy consumption of buildings is significant on the national scale. At the moment, buildings and building represent slightly over 40% of the end-use of energy. Traffic consumes close to 20% of all energy. Similarly, buildings and building cause about 40% of Finland’s greenhouse gas emissions while traffic causes about 20%. ERA 17-report includes an estimate of the development of energy consumption with respect to the stock of buildings at various points in time. The consumption of heating energy attributable to residential buildings and service buildings can be reduced by more than 20% by 2020 and by more than 50% by 2050. Energy generation will be based almost entirely on emission-free forms of generation in 2050. Then the emissions from the built environment will also be extremely small.

Figure 2.2. The significance of the assessed field of industry in reducing CO$_2$ emissions in Finland. Source: Gaia Consulting Oy. CO$_2$ emissions of energy generation and use from TEK and UIL scenarios.

The world markets for sustainable technology are undergoing a period of powerful growth. Depending on how they are defined and delimited, this market sector has experience annual growth of 10-30 percent. Growth has been fastest in the industrialising economies. For example: The markets in China, India and Brazil for renewable energy increased 14-fold and amounted to USD 26 billion in 2004–2007. IEA has estimated that halving the world’s energy-based emissions would require annual investments totalling USD 1 trillion. This sum would cover the investments in research and development focusing on sustainable technology, the additional costs of low-emission techniques, and private investments in the energy sector.

The international growth estimate regarding sustainable technology and the significant drivers of energy conservation (technological development, changes in consumers’ values, political steering) will impact on the future of society with exceptional force. Its ramifications into engineers’ expertise, employment opportunities, and workplace environment are exceptional even in historical terms. This is why we need to examine the changes caused by sustainable technology with particular care.
3 WOOD-BASED BIOECONOMY

Renewable natural resources – wood and other biomass forms – are used sustainably and in diverse ways in bioeconomies in making products and in producing services. Biomass fibres and other components replace non-renewable natural resources, and new applications are expected to be found for biomass. Services based on the immaterial values of natural resources and business are also aspects of bioeconomies.

This assessment focuses on the possibilities of utilising forest reserves (Fig. 3.1) because Finland’s constantly increasing and sustainable forest reserves form the core of the country’s bioeconomy and constitute its strategic competitive factor. Forest resources will be used in increasingly diverse ways in the bioeconomies of the future. A variety of invaluable innovations originate from the forest resources and their use offers a rich diversity benefits to society.

Figure 3.1. Possibilities for utilising forest resources. Source: Gaia Consulting Oy

3.1 SIGNIFICANCE FROM THE VIEWPOINT OF CLIMATE CHANGE

Replacing non-renewable raw materials and energy sources with renewable natural resources enables us to significantly reduce greenhouse gas emissions and mitigate climate change. In Finland, renewable energy satisfies 28.5 percent of the final consumption; this figure is among the industrial worlds highest. Most of this (2/3) is energy of wood origin obtained from forest-industry process by-products and waste, and felling waste and tree stumps. The demand in the future for energy wood will increase, and this requires investments in the development of infrastructure and wood harvesting technology and in the long-term attending silvicultural work. However, the industrial converting of wood can yield multiple economic and climate benefits when compared to burning of wood.

The growth of bioeconomies will result in increasing utilisation pressure on forests and competition for wood. The volume of wood consumed and changes in it will also cause changes in forest ecosystems and their carbon balance. For example: Many uncertainties are still connected to the environmental impacts of the use of forest-based energy.

The expectations on next-generation fuels are also high in the development of biofuels for vehicles. As regards the first-generation biofuels for vehicles, the use of biomass suitable for food as the raw material in their production has been questioned. Waste is used along with other raw materials in the production of second-generation biofuels and biofuels of subsequent generations, and this means that fuel production no longer competes with food production.
The ever-growing forests and long-lived wood products also serve as efficient carbon sinks – albeit that many uncertainties are still related especially to the computation of the greenhouse gas balance of the forest soils. For example: A wooden detached house stores some 30 tonnes of carbon, which corresponds to the family’s emissions over a period of 10 years or their 10 holidays spent in Southern Europe. It has also been noted that making and transporting wooden construction products produce very little carbon dioxide compared to other construction products.

### 3.2 Description of Finland’s Present Situation

The know-how and business related to bioeconomy and forest resources are both vast in Finland. Finland’s forest cluster is an internationally renowned user of wood and biomass, and a supplier of technology and chemicals. Finland is the EU’s leading country in the energy-generation use of wood and other biomass forms. The current conversion-value pyramid of the wood-based bioeconomy is shown in Fig. 3.2.

![Conversion-value pyramid of the wood-based bioeconomy.](image)

Source: Finnish Forest Industries Federation

Finland’s forest resources are constantly increasing as the drain on these resources is less than annual increment, and the country’s biomass resources as a whole are among Europe’s largest. Sustainable growth in a situation of pressure being imposed on renewable natural resources is turning into a strategic success factor, and the significance of Finland as the possessor and utiliser of renewable natural resources could increase. A lot of bioeconomy investments have been made in Finland on, especially on research related to forest resources and their use, and to innovations in centres of excellence such as Metsäklusteri Oy. Finland’s industrial background, the resident expertise in wood processing and water treatment, and the firmly-seated process-industry tradition enable excellent opportunities for the country to develop into a significant bioeconomy actor.

Policy measures have been implemented and continue to be implemented especially to promote the increased use of bioenergy and biofuels. The availability of wood and reinforcing of innovation activity in the field have been targeted by way of a number of public measures, but these are not as systematic or concrete in their impacts or objectives.

The central drivers and uncertainties of the future as regards the possibilities of bioeconomies and the utilisation of forest resources are interconnected to the world economy, climate change, political measures, developments in specific fields of industry, and development in companies. Central drivers
and uncertainties are connected also to the availability of wood, the utilising of forest resources for energy, substitute products, innovations, and customers’ and consumers’ needs and habits.

The scarcity of natural resources and their increasing value due to growing demand for them impose pressure on the more diverse and productive utilisation of renewable natural resources. In order to give birth to a bioeconomy characterised by high value-added and in order to utilise the solid expertise that there is in Finland in the utilisation of bioprocesses, we need forest resource utilisation characterised by value added being produced and having export potential, and we also need new ways of thinking and doing things that cross existing sector and industry boundaries.

3.3 CHANGES IN EXPERTISE NEEDS AND JOB OPPORTUNITIES

3.3.1 DEVELOPMENT WITHIN THE FIELD AND EXPERTISE NEEDS

Bioeconomy is an economy where the boundaries between forest industries, chemical industries, and energy industry and the operational points of focus are changed. Engineers play central roles in wood-based bioeconomies, but other actors are also needed, and the boundaries of engineers’ job assignments are subject to change. As regards bioeconomy matters, Finland’s firmly established engineering expertise needs to be harnessed to innovative product expertise based on customers’ needs in order for the desired value added to be created from Finnish wood. The development and commercialisation of existing and new products and services need business developers able to find new international business opportunities at the customer interface.

The importance of expertise in materials sciences and chemistry becomes emphasised in growing bioeconomies; this is a precondition for the innovation and manufacturing related to new biofuels, biochemicals, and other bioproducts. The basis must be in existence in the form of solid expertise in basic sciences such as chemistry and physics whereby the properties of wood can be used in the best possible way.

Professionals in the field of construction are required to be in possession of excellent readiness in designing versatile wooden buildings in order that the basis for the development of new building solutions will be a solid one and that wood gains a competitive position as a construction material. The point of focus in the traditional areas of the forest industries will shift over to converted products, and this will require expertise related to modifying and converting wood and wood fibres. As the use of biomass increases, more firmly established management of the procurement of biomass and of the value and logistics chains will be required. Resource efficiency and overall optimisation of systems will also play greater roles than before.

The expertise related to environmentally-friendly combustion and boiler technology with respect to bioenergy is already very well established in Finland. The associated planning and machinery-and-plant expertise is needed in the future as well because they provide a firm foundation for exports from Finland. The merging of ICT and automation with expertise in process and mechanical engineering opens up new paths.

The development of service business within this field is not as marked as in the other fields examined here, albeit that local heating-energy entrepreneurship in relation to forest-chip-based energy services is possible.

3.3.2 CHANGES IN EMPLOYMENT OPPORTUNITIES

There are obvious growth areas with the field of wood-based bioeconomy in which job opportunities for engineers will also probably increase. The central areas of expertise related to the wood-based bioeconomy and an advance estimate of the relative changes in the demand for engineers in the future in these areas are shown in table 3.1. The changes are based on the findings of the workshop implemented in early 2011, reports published by various parties, and expert estimates. The arrows in the table depict estimates of the direction of changes in the demand for engineers in the manner shown below. These estimates provide the basis for the estimates of the future demand for engineers
as presented in Chapter 6.

<table>
<thead>
<tr>
<th>Changes in demand for engineers</th>
<th>Reasons and further details</th>
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| New biomaterials and bio-products | • Engineers will be needed as enablers of new openings in new product areas and new applications providing substitutes for non-renewable materials  
|                                | • Biorefineries and other investments will provide opportunities  
|                                | • Boundaries between forest industries, chemicals industry, and energy industry will become blurred |
| Wood in construction | • Growth of wood construction will require engineering expertise in both planning and manufacturing  
|                                | • Wood construction will grow both in Finland and abroad |
| Bioenergy and biofuels | • International objectives related to bioenergy and biofuels use will require significant increases of their shares  
|                                | • There will also be international demand for Finnish technological expertise |
| Biomass procurement and logistics | • More personnel will be needed in increasing the use of home-grown wood in biomass procurement and logistics; especially manual workers, but also engineers |
| Current wood-products industry | • As construction material provider will retain its position as employer of engineers. Shift over to more value-added products will require engineering expertise |
| Current paper industry | • Focus will shift to converted paper and paperboard products and products with higher value-added |

Table 3.1. Central areas of expertise related to the wood-based bioeconomy and changes in the demand for engineers

**New biomaterials and bioproducts:** Here engineers will be needed as enablers of new product branches and in providing substitutes for non-renewable materials in new applications. Investments in bioconverters and other investments create possibilities for the development and manufacturing of new biomaterials and bioproducts. The boundaries between forest industries, chemicals industry, and energy industry become more and more obscure, and engineers will be able to switch between them with ease.

**Wood construction:** Engineers’ expertise is needed here in both planning and manufacturing. Strong growth in wood construction and renovation and new construction in Finland and abroad enhance the business of enterprises operating in this field and add to the need for engineers.

**Bioenergy and biofuels:** National and international objectives related to the use of bioenergy and biofuels require significant enlargement of their share. Moreover, Finnish technological expertise in the area of clean technologies also promotes the demand internationally, and this in turn increases the need for engineers.

**Biomass procurement and logistics:** More people are needed in promoting the use of home-grown wood. There is demand especially for manual labour in this area as well as for engineers.

**Current wood-products field:** This will retain its position as a materials producer and as provider...
of jobs for engineers. The transition to value-added products requires engineering expertise, and this growth is evident in wood construction in the above table. Design and composite products are examples of new know-how-intensive content and they bring value-added products to the field.

**Current paper industry:** The focus will shift to converted paper-and-board products and to products possessing increasingly more value added. This growth and shift in focus will be evident above also with new biomaterials and bioproducts.
4 SMART GRIDS

Technological development, the need for more renewables-based energy, the promotion of energy efficiency, and the repeated debate over the quality of the distribution of electricity cause major pressure for change on the networks. The development and adopting of smart grids have been proposed as a solution to meeting these growing needs. Smart grids is a term used when referring to “electricity distribution networks, which satisfy future needs and whose efficiency, reliability and flexibility have been developed through automation technology, information technology, and communication technology, and using which consumers can participate more than at present in the functioning of the electricity market via a two-way flow of information. These networks support the distribution of increasingly distributed energy generated using renewable energy sources and new technologies for the storage of electricity.”

Some the typical functions associated with smart grids are virtual power plants which bring the generation of electric energy into a single management wholeness, the distributed generation of energy, the active use of versatile methods of storing electricity, smart household appliances, and electricity meters providing real-time information. The problems related to technology do not significantly restrict the use of smart grids any longer because the majority of the components and technologies required by them already exist. The biggest challenges, on the other hand, are the high investment costs related to their introduction, the challenges related to the allocation of investments, the underdeveloped nature of the services, and the difficulty in determining customer benefits. The partial factors involved in smart grids in the Kalasatama site planned to be built in Helsinki are shown in Fig. 4.1.

![SMART GRID PARTIAL FACTORS](image)

Figure 4.1. A smart energy system is comprised of features such as electricity generation based on local renewable energy sources, e.g. solar power and wind power, an infrastructure favouring the use of electric cars, storage of electricity, and energy-efficient building automation installed in residential and commercial buildings. The figure is connected to the building of Kalasatama in Helsinki. 
Source: Helsingin Energia/Matias Teittinen

Smart grids are part of a broader-in-scope international and national energy and electricity market vision. According to the European Commission, the use of smarter grids is essential; e.g. for the EU’s 2020 objectives to be reached. For Finland, the EU’s 2020 Programme lays down the objective of 38 percent of renewable energy sources, which means a dramatic increase in the generation of electricity.
using renewable energy sources, and especially as regards the use of wind power. This in part serves as an encouragement for the construction of smarter grids. Finland’s Energiamarkkinanvirasto (Energy Market Authority) has drawn up a roadmap for the developing of the country’s grids operation extending to 2020, and smart grids play an important role in this plan.

### 4.1 Significance from the Viewpoint of Climate Change

Smart grids can reduce carbon dioxide emissions by significantly increasing the efficiency of the networks, by leading to development of the functioning of the electricity market, by reducing the consumption of electricity, especially during consumption peaks, and by enabling the large-scale utilisation of renewable and distributed energy generation. In Finland, smart grids are believed to enable carbon dioxide emissions to be reduced by about 2-5% by the year 2020. Smart grids are also a precondition for electrifying of traffic, which will have an important role in the long-term mitigation of climate change. The foremost impact mechanisms of smart grids on climate change are presented in Fig. 4.2.

Direct savings are achieved in regard to the development of grids when new materials reduce energy losses during the transmission of energy, especially over long distances, and when advanced network control improves the balancing of demand and supply, and thereby the reliability and efficiency of the networks. Smarter grids can enable better efficiency in the use of energy by consumers and companies by optimising the use of energy in buildings and production plants.

![Figure 4.2. Smart grids' foremost direct and indirect impact mechanisms with regard to climate change. Source: Gaia Consulting Oy](image-url)

Remotely-read meters are in a central role in improving the functioning of the electricity market as they provide the necessary preconditions for market-based demand elasticity and distributed production specific to usage locations. The intention is for real-time energy-consumption data to activate the customer to monitor his own consumption and to endeavour to reduce it. Fluctuating rates can be used in steering consumption away from periods of consumption peaks and by also making use of the opportunities for storing electricity less reserve capacity (which often relies on fossil fuels) is needed.

Smart grids enable both large-scale industrial production based on renewable energy and produc-
tion at the household level. Distributed generation means that electricity can be generated closer to the point of consumption, which also means that transmission losses are smaller. Furthermore, increased application of distributed generation can improve the quality and reliability of the distribution of electricity.

4.2 DESCRIPTION OF FINLAND’S PRESENT SITUATION

Finland has experience of long standing in the construction and development of efficient grids. Moreover, Finnish expertise in the ICT and electricity-and-electronics sectors support Finland’s competitiveness especially in the management and operating of smart grids. Network technology has been studied a great deal in Finland, and all of Finland’s universities of technology have been involved in the associated research projects. The already intensive entrepreneurship involving smart grids is being further accelerated through the launching of the “Älykkääät sähköverkot ja energiamarkkinat” (Smart Grids and the Energy Market) by the company Cleen Oy. According to estimates based on the figures presented in the Smart Grids Technology Community’s strategic study agenda, EU member states will have to invest perhaps as much as €300 billion in the distribution grid infrastructure during the coming 30 years, and consequently there could be international demand also for Finnish expertise.

The point in time for investing in smart grids is excellent in Finland since the distribution and transfer networks constructed for the most part in 1960–1980 are reaching their upgrading and replacement age. Another incentive for developing smarter grids is provided by the Government Decree issued in 2009 according to which at least 80% of small-scale consumers’ metering points must be within the sphere of remotely-readable hourly readings by the end of 2013. Significant investments are also being implemented in renewing building-specific networks and in automating of network technology. The new regulations are also aimed at promoting functions such as electricity consumption measurements and energy-efficiency services. With investments increasing, it is estimated that there will be a shortage of staff skilled in grid work, and this applies not only to grid construction, but also to planning and product development.

The business related to grids is natural monopoly business because it is not profitable for society to upkeep competing grids. Because of this monopoly aspect, the authorities regulate the grid business. Previously, regulation focused on pricing and cost systems, but nowadays associated values include ensuring availability, quality, and reliability. A feature characteristic of the development of smart grids is the rapid increase especially of European regulation and steering, and this is also reflected in the situation in Finland. The foremost drivers of smart grids at the national and EU levels are shown in Fig. 4.3.
Several uncertainty factors are connected to the development of smart grids and to Finland’s possibilities to succeed in this highly competed field of industry. On the one hand, changes in the world economy, e.g. the EU’s economic crisis, and, on the other hand, the ability to provide sufficient economic support for this capital-intensive and risky sector, and the evolvement of the grid business from its state of being a natural monopoly into a competitive applier of new technologies… these all impose challenges for smart grids and they bring with them uncertainty.

4.3 CHANGES IN EXPERTISE NEEDS AND JOB OPPORTUNITIES

This chapter sets out briefly a vision regarding smart grids of the future, their properties, and their pivotal applications. Based on this, the fields of expertise are further divided into more precise expertise needs. Because most of the technologies required for smart grids already exist, the foremost expanding expertise needs can be addressed fairly reliably when these become common. However, it is not possible to present more precise numerical figures at this stage of development.

4.3.1 DEVELOPMENT WITHIN THE FIELD AND EXPERTISE NEEDS

A central aspect related to smart grids is the virtualisation of electricity sales and of grid functioning. This indicates that all information on power consumption and generation at different points is presented in real time, and customers can choose from whom and when they buy their electricity; e.g. this can be done over the Internet. The central future actors in virtualisation are virtual power plants, which bring together the electricity generated at numerous generation points, package it, and then sell it as customised products to their customers. In so doing, they act as retailers between the various power generation units and consumers. Concurrently with this, the increase in power generation in households, evolving possibilities for storage of energy, and improving the efficiency power
consumption assisted by smart household appliances, for instance, enable customers to influence their power consumption far more than before. Virtual real-time electricity trading opens up opportunities for numerous innovative products and for business opportunities connected to customers’ evolving consumption management options. Lightening of the regulations related to the grids is a precondition for advanced virtual electricity trading and for enlarging the customers’ possibilities to influence matters.

The significance of distributed power generation and households’ power generation is expected to significantly increase during the next couple of decades. In addition to wind- and solar-power units, these generation units could include bioenergy and CHP systems on farms in Finland, and the increasing use of wood chips in small-scale generation of electrical power. When the price of electricity goes up and as technologies are developed further, there will be endeavours to develop new methods of generating electricity.

In the future, households will be in a position, not only to buy electricity from the grid, but also to sell electricity to the grid when their own production exceeds their consumption or merely to swap their own renewable-energy-based electricity for the cheaper electricity generated using fossil fuels. The important things is for the meters used to monitor the consumption of the electricity to be such that they also enable the measurement of energy generated by households. This ensures that the possibilities of the future are not excluded by technological solutions.

Another change impacting on households is the increase in building automation, which cuts the power consumption of smart household appliances. Typical examples of smart household appliances are refrigeration devices, which optimise their electricity consumption in accordance with the rate, i.e. they use more power when it is cheaper. The combined management automation related to electricity consumption, heating, and air conditioning, which also takes into account the real-time prices of electricity and heating energy and optimises consumption with prices and consumption data as the bases, can be expected to be part of everyday living sometime in the future. The management of these so-called smart houses also involves diverse ICT and mobile applications, which enable the management of power consumption of the home from wherever and whenever. For example: A stove which has been left on or lights that have not been switched off can be controlled using a mobile phone. Smart houses will increase in numbers as smart meters and real-time electricity pricing, especially in new buildings, but the development of building technology solutions is also being increasingly reflected in the planning and implementation of renovation of existing older buildings.

The role of storage of energy will significantly increase as versatile energy-storage solutions competitive in their prices become available. As the efficiency rates of storage improve and as electric cars increase in numbers, the storage of energy will become profitable on both large scale and on the household scale. The popularity of new applications drives forward battery technology and the development of electricity storage forms suitable for cars and electronic devices.

The starting point for the future vision is determined research and investments in the field of grid control and optimisation, and in information management and information-related security systems. The development of the network to serve the transmission of electricity, not only from the generation units to the customers, but also from customers to customers, requires advanced smart meters and massive data collection management systems, information management systems, and information utilisation systems. The levelling out and optimisation of energy generation and consumption are considerably more complex when generation is distributed among numerous units and an increasing part of it is covered by non-elastic generation based on renewable energy sources. The data security risks related to smart electricity meters are widely understood and heeding these risks requires the setting up of a sophisticated data security system.

Some of the other evolving areas are large-scale utilisation of waste-based energy and of the heat dissipated in the generation of electricity, and the possible increase in numbers of DC grids. The electricity lost when transmitting power over the DC grid is less than that lost by AC grids, and consequently it may be profitable, for example, to make significant investments in solar energy generation capacity in Africa and then conduct that energy to the European grid system. Also the standards and environmental markings related to grids, electricity generation, and smarter electrical apparatuses are bound to increase in number and thereby add to the need for verifying and validation. Furthermore, operating smart grids requires familiarity with EU regulations and standards.
4.3.2 CHANGES IN EMPLOYMENT OPPORTUNITIES

Finland is in a position to be a pioneer in the introduction of smart grids and to compete on equal footing in the manufacturing and delivering of the equipment, software, and systems, especially for ICT applications. If Finland fails to retain its position as a pioneering market, then Finland will also not be able to offer product development jobs in significant numbers.

Perhaps the most important and increasingly sought expertise associated with smart grids is connected to ICT applications. The real-time processing of the huge data amounts sent by the smart meters and supporting the management of grids require new ICT systems and the ability to rapidly collect, manage and utilise huge masses of data. In addition, ICT expertise is needed in situations such as implementing the management systems related to smart buildings and household appliances. Especially expanding fields of ICT expertise are data processing, telecommunications, information processing systems, and mobile technology.

The increasing complexity of power generation and consumption, together with the generation of renewable energy, result in significant need for expertise related to grid management and optimisation. The balancing of power generation and consumption is becoming constantly more challenging, and this adds to the demand for engineers specialised in system management, planning, and optimisation. Concurrently with these developments, the setting up of virtual power plants and corresponding electrical power management units increases the demand especially for electricity- and electronics expertise.

The pivotal fields of expertise related to smart grids and an advance estimate of the relative changes in the future demand for engineers in these fields are shown in Table 4.1.

<table>
<thead>
<tr>
<th>Changes in demand for engineers</th>
<th>Reasons and further details</th>
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<tbody>
<tr>
<td>Management of power grids</td>
<td>- Growth of distributed and renewable-energy-sources-based energy generation (20-20-20)</td>
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<tr>
<td></td>
<td>- Real-time pricing -&gt; customer response</td>
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<tr>
<td></td>
<td>- Grid automation and virtual power plants</td>
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<td>Distributed energy generation</td>
<td>- Growth of distributed energy generation</td>
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<td></td>
<td>- Creation of new service wholeseness</td>
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<tr>
<td>ICT-sovellukset</td>
<td>- Data communication network required to support grid management</td>
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<tr>
<td></td>
<td>- Rapidly increasing data transmission, e.g. related to smart meters</td>
</tr>
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<td></td>
<td>- Data security</td>
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<tr>
<td>Sahköverkkojen rakentaminen</td>
<td>- Need for main grids &amp; high-voltage grids will probably diminish</td>
</tr>
<tr>
<td></td>
<td>- Micro-grids are unlikely to significantly gain ground in Finland</td>
</tr>
<tr>
<td>New customer products and</td>
<td>- Smart meters and household appliances, electric cars, etc.</td>
</tr>
<tr>
<td>services</td>
<td>- Real-time pricing – new markets</td>
</tr>
<tr>
<td>Energy storage</td>
<td>- Energy storage applications, e.g. cooling/heating energy storage</td>
</tr>
<tr>
<td></td>
<td>- Electricity storage</td>
</tr>
</tbody>
</table>

Table 4.1. Fields of expertise related to smart grids and the associated changes in the demand for engineers

Conventional construction of grids is the only area of employment for engineers in which job opportunities could even be reduced as a consequence of the development of smart grids. In Finland, the building of micro-grids or the building of significant DC grids is unlikely. At the same time, conventional high-voltage grids will be needed less than before as distributed power generation becomes more widespread and as grid materials improve.

Distributed energy generation and household-based energy generation underlie increasingly complex energy generation and consumption. Distributed energy generation and generation of energy at the household level are bound to increase as wind power and other lesser renewable-energy-based electricity generation forms become more common. This adds to the need for people with expertise in fields such solar, wind, bio- and CHP energy. Furthermore, it is possible that new technologies focusing on small-scale energy generation may come to the fore, and add to the need for expertise...
in the field in question.

The need for experts in energy storage will also increase. Among particularly rapidly growing fields of expertise in this field are electric batteries and other chemical methods of storing electricity, including thermodynamic applications.

In addition to management of ICT applications and grids, perhaps the biggest growth area is the development and commercialisation of new customer products and services, and the improvement of the usability of new solutions. Smart grids open up numerous new business opportunities for innovative products and applications. For example: The utilisation of the new electricity market and development of versatile electricity products and smart house solutions are expected to lead to the creation of entirely new forms of business. Among the pivotal fields of expertise are availability, automation, electricity-and-electronics, and mobile technology. Expertise will be in high demand also in design know-how, in-depth understanding of customer needs, and innovation know-how.

All in all, smart grids will have a significant positive impact on engineers’ job opportunities. Especially engineers with electricity-and-electronics expertise, ICT expertise, and mobile expertise, and system management and optimisation associated with grids will be in increasing demand in connection with smart grids. Furthermore, the expertise needed in connection with distributed energy generation, storage of energy, and actual development of new products will increase. Certain other expertise needs are also expected to arise depending on future technological innovations.
5 SUSTAINABLE URBAN AND COMMUNITY STRUCTURE

Sustainable urban and community structure here refers to the built-up environment that has been implemented cost-effectively applying safe, healthy, pleasant, and functioning built-up environment and its planning with due consideration for environmental factors. This includes buildings and their construction, renovation, heating systems, waste disposal, and water supply and wastewater systems. The urban and community structure has a significant impact on traffic, but the emissions produced by traffic are also impacted by factors such as choice of fuel and the widespread introduction of electric vehicles. Here, we have not focused on traffic as part of the urban and community structure and its development, but attention is attached to the planning of urban and community structures and its impact on traffic solutions as part of sustainable urban and community structure.

It is a matter of great relevance for distributed energy generation that there be space and possibilities for the generation of electricity and heating energy in built-up areas. The development of distributed energy generation is significantly affected by what the objective is in the reduction of emissions of greenhouse gases. On the other hand, restricting of particulate emissions locally production can hinder the introduction of certain forms of energy generation. Solutions related to distributed energy generation are described in more detail in connection with smart grids. Fig. 5.1 illustrates the partial areas of sustainable urban and community structures.

Urban and community planning plays a pivotal role in the building-up of new areas and in promoting renovation and supplementary contraction of areas with an existing building stock. Urban and community planning is where many matters are determined affecting traffic, energy generation, and water supply and wastewater treatment, and consequently these decisions largely decide the environmental impacts of the area.

Urban and community structures develop in accordance with the residents’ needs and wishes, and it is important for sustainable solutions to be available for different types of housing. A special characteristic in Finland is the large number of holiday homes (a.k.a. second homes). The assessment looks at these holiday homes as part of the overall development of urban and community structures.
5.1 SIGNIFICANCE FROM THE VIEWPOINT OF CLIMATE CHANGE

Sustainable urban and community structure is of major significance from the viewpoint of change. In Finland, the energy consumed by buildings and the emissions released during the construction stage amount to close to 40% of the country’s total emissions of greenhouse gases. Sustainable district planning can also have a significant impact of the emissions of traffic; these amount to approx. 20% of the country’s total emissions.

Much attention has been paid to the energy consumption of buildings during the past few years. Especially the building regulations adopted in 2010 and the mandatory energy categories for new buildings have promoted this development. New building regulations come into effect in 2012, and their objective is to further reduce energy consumption by 20%. As the lifetime energy consumption of buildings further diminishes towards a level where they annually generate the same amount of energy as their owners purchase from the grid or as fuel, greater emphasis is placed on the share of the energy consumed and the emissions caused in producing the construction materials and during construction of the buildings.

5.2 DESCRIPTION OF FINLAND’S PRESENT SITUATION

Public-sector actors play a significant role in the creation of preconditions for sustainable urban and community structures in Finland, e.g. via urban and community planning. There are already numerous examples the world over of areas where the focus in planning has included the environmental impacts of construction. In Finland, the first such areas are under planning where the area’s overall energy efficiency is deemed to be an important factor. Public-sector actors have important roles both as developers and real-estate property owners via renovation construction and new construction, and as parties involved in energy generation and waste disposal. The public sector can impact private actors also by way of the example it sets.

The energy efficiency of buildings has been the subject of study in Finland for many years already. However, there are relatively few demonstrations of competitive advantage to be gained internationally in the current sub-areas of sustainable construction. As is generally the case in the construction business, the actors are often specialised in certain products and the production chains spread out. As regards district-based solutions, district heating and joint-generation of electricity are practised with extremely high efficiency in Finland.

Wood-based construction is gaining significance in Finland. Wood-based construction also supports development where more attention is paid to the emissions of the construction materials and to emissions during construction.

5.3 CHANGES IN EXPERTISE NEEDS AND JOB OPPORTUNITIES

The central area of expertise related to sustainable urban and community structures’ sub-areas and an anticipating estimate of the relative changes in the demand for engineers in the future in these sub-areas are shown in Table 5.1. The changes are based on the findings of the workshop implemented in early 2011, reports published by various parties, and expert estimates. The arrows in the table depict estimates of the direction of the changes in the demand for engineers ranging from significant growth to significant reduction. A more detailed description from the significance of the arrows is provided in Chapter 3. The estimates form the basis for the estimates presented in Chapter 6 for future demand for engineers.

When estimating the significance of the different sub-areas from the viewpoint of future development, three significant themes come to the fore:

- Evaluation of the overall environmental effects of the system and communicating regarding them
- Development of the urban and community planning process such that environmental aspects are heeded on a broad front
Supporting innovativeness in urban and community planning and enabling pilot construction

<table>
<thead>
<tr>
<th>Changes in demand for engineers</th>
<th>Reasons and further details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy-efficient renovation construction</td>
<td>• Need for renovation construction will increase in coming decades</td>
</tr>
<tr>
<td>Planning</td>
<td>• Energy-efficiency requirements in connection with major renovations</td>
</tr>
<tr>
<td>Construction industry</td>
<td>• More stringent regulations for buildings’ energy efficiency</td>
</tr>
<tr>
<td>Project implementation</td>
<td>• Development of quality and longevity</td>
</tr>
<tr>
<td>Distributed energy generation</td>
<td>• Development and management of new technologies, e.g. building technology</td>
</tr>
<tr>
<td>Transportation planning and district planning</td>
<td>• Energy-efficient and recycleable construction materials</td>
</tr>
<tr>
<td>Water supply and waste disposal systems</td>
<td>• Objective: Nearly zero-energy house -&gt; Heeding renewable energy sources in planning of buildings and districts</td>
</tr>
<tr>
<td>Services</td>
<td>• Quality management of delivery chains and construction projects</td>
</tr>
</tbody>
</table>

Table 5.1. Sub-areas of expertise related to sustainable urban and community structures and associated estimates regarding changes in the demand for engineers

The evaluation of the overall environmental effects of the system provides an essential foundation for all legislative and planning work. Lifespan assessments enable information to be obtained on matters such as the environmental effects of alternative district solutions and traffic solutions or ways of construction and material alternatives. Engineering expertise is needed in doing these assessments and in communicating about them to decision-makers and local residents. For example: It is possible to assess the effects of changes in legislation with the help of simulation, and this then enables displaying the general effects of changes from the viewpoint of the environment.

The urban and community planning process could be developed such that a new set of norms could be developed for the purpose of assessing the quality of the planning. These norms could in some way oblige paying attention to the following matters:

- District heating solutions
- Geothermal reservations in the area
- Adapting to climate change, e.g. floods caused by heavy rains
- Heeding of the microclimate from the viewpoint of buildings and small-scale wind power harnessing
- Pleasantness of the living environment
- Getting residents to participate in planning
- Supporting of small communities and provision of services

The planning of norms for urban and community planning and the evaluation of the quality of the urban and community planning process also involves engineering expertise.

Nowadays, the inflexibility of the planning process is often an obstacle to innovative construction. Strict building regulations can also considerably hinder the development and testing of new solutions. Urban and community planning could be modified so that only the interfaces of a certain area would be defined; e.g. with respect to electrical, heating, and water supply systems. Building regula-
tions could be such that they would enable exemption from current regulations to pilot construction belonging to the sphere of research and development whereupon the testing of progressive construction modes would be possible without legislative changes being necessary.

**Energy-efficient renovation** is estimated to provide slightly more jobs for engineers than today. Renovation can help in achieving significant reductions in the emissions of greenhouse gases, but for the present we do not know how the energy efficiency of renovation construction will be regulated in the future. Engineer expertise will be needed in both the planning and implementation of renovation projects and in the development of new more efficient action modes. Also, the drawing up of energy reports for buildings, the drawing up of energy certificates, and the enlargement of their use will have effects on engineers’ future employment.

**Planning of new buildings, the construction-industry, and the implementation of construction projects** are estimated to provide significantly more job opportunities for engineers than at present. The increasingly strict building regulations and concurrently developing management of the quality of construction impact on building planning. New technologies and new building-technical solutions are being developed continuously, and this must also be taken into account in the planning of buildings.

Engineer expertise in the construction industry often required in the development of new construction materials and in enhancing the recyclability of materials. The use of certain construction materials is bound to decreases because of factors such as their energy-intensive manufacturing processes. Moreover, the implementation of construction projects will need more engineer expertise, e.g. in energy-efficiency planning and quality management of projects. Quality management is in a position greater significance than before in the construction of energy-efficient buildings because the new kind of management of construction physics, including the use of new materials. Furthermore, certain production technologies can be developed for the needs of construction, e.g. robotics. Even if the development work is not done in Finland, Finnish engineers’ expertise may be needed in the utilisation of new production technologies in the construction industry.

**Distributed energy generation** is estimated to provide slightly more jobs for engineers in the future. According to the Directive on the Energy Performance of Buildings (2010/31/EU), new buildings must be “nearly zero-energy buildings” by the end of year 2020. In practice this means for Finland that local products based on the renewable energy sources must be installed in buildings. Engineer expertise is needed for sustainable urban and community structures when these solutions are integrated in the buildings. Furthermore, there may be need for engineer expertise in the planning of district heating solutions in built-up areas.

**Traffic planning and district planning** are estimated to employ slightly more engineers in the future than at present. Attention needs to be paid in planning to the different needs of urban and rural areas when addressing the matter of energy-efficient traffic. As a general means of reducing the need for traffic, it is necessary in planning to pay special attention to local services and to the pleasantness of the surroundings. As regards planning of areas, this imposes more diverse requirements than before and engineers’ expertise is expected to be broader in scope.

**Planning of water supply and waste disposal systems** are estimated to provide the present or slightly improved number of jobs for engineers. As regards water supply systems, it will be possible (as sustainable urban and community structures develop) to adopt solutions such as recovery of heat from waste waters or use rainwater more efficiently. The management of material flows and the possibility to develop district-specific waste disposal solutions become emphasised in waste disposal.

**Services related to sustainable urban and community structures** are estimated to offer slightly more jobs for engineers. For example: New services may be developed for monitoring residents’ energy consumption and improvement of energy efficiency. Furthermore, the demands of maintenance and servicing of new buildings will develop and new services can be developed for them. Generally speaking, sustainable urban and community structure means centralised services in urban areas and in rural areas it means focusing of services based on local conditions. Especially new services and the development of new service concepts, e.g. for building maintenance and service, improvement of residents’ energy efficiency, can provide jobs for engineers in the future.
6 DEMAND FOR ENGINEERS NOW AND IN THE FUTURE IN AREAS OF WOOD-BASED BIOECONOMIES, SMART GRIDS, AND SUSTAINABLE URBAN AND COMMUNITY STRUCTURES

The estimates presented in this chapter are based on TEK’s and UIL’s own data collected on their members’ employers and their fields of industry. The distributions concerning members have been generalised to apply to the field of industry as a whole. The different fields of industry are examined in more detail in Chapters 3-5, and tables in these chapters provide the basis for the estimates presented in this chapter regarding the future demand for engineers in the said fields of expertise and the direction of the changes in demand. The presented estimates should be seen as guidelines and they are based on how the future is seen at this moment in time. It should also be noted as regards the estimates that the speed and timing of the changes in demand can vary greatly and that they are impacted significantly by factors such as technological innovations, international success of companies, growth, and government policies.

6.1 ACADEMIC ENGINEERS AND ARCHITECTS

At the moment, some 9% of academic engineers and architects are employed in positions connected to wood-based bioeconomies, 1% work in jobs connected to smart grids, and 20% in jobs related to sustainable urban and community structures (Fig. 6.1). All in all, there were approx. 63,000 academic engineers and architects active in the working life in Finland at the end of 2010.

![Figure 6.1. The shares of academic engineers and architects working in the fields of industry addressed in this report in comparison to all members of their professions in Finland at end of 2010](image)

Table 6.1 presents estimates of the numbers of academic engineers and architects employed in positions connected to bioeconomy, smart grids, and sustainable urban and community structures at the moment and in the future.
Academic engineers and architects 2010 | Estimate for 2030 | Estimate for 2050
--- | --- | ---
Wood-based bioeconomy | 5 300 | 6 000 | 7 500
Smart grids | 500 | 2 500 | 5 000
Sustainable urban and community structures | 12 700 | 14 500 | 15 000
Others | 44 700 |  | 
Total | 63 200 |  | 

Table 6.1. Estimates of the numbers of academic engineers and architects employed in positions connected to bioeconomy, smart grids, and sustainable urban and community structures at the moment and in the future

As regards wood-based bioeconomy, the growth in demand for engineers in 2030 is explained by the growth in demand for engineering expertise related to new biomaterials and bioproducts, wood construction, bioenergy, biofuels, and biomass procurement and logistics. For example: The share of business among chemicals industry enterprises based on the wood-based bioeconomy will increase and the traditional boundaries between the forest industries, chemicals industry, and energy industry will become less distinct. The increase in the need for engineer expertise continue until 2050 because the demand for solutions involving the wood-based bioeconomy will increases and this filed also possesses strong export potential.

The increase in demand for engineer expertise related to smart grids is partly the result of their partial merging to become part of conventional energy generation and electricity grid functioning. Concurrently with this development, smart grids enable the emergence of totally new areas of business, e.g. real-time electricity market. The development work and piloting related to them will receive powerful support at both national and EU level, and several EU directives encourage utilisation of smart grids. The EU’s emissions reduction objective of 80% by the year 2050 means that it is very likely that the inputs into examining the possibilities of smart grids and their utilisation extend long into the future and thereby call for increasing expertise at least until 2050.

However, it is difficult to estimate the growth potential of smart grids. Firstly, the growth potential depends largely on the delimitation; e.g. will smart household appliances and energy generation based on renewable energy sources or households’ energy generation be included. If smart household appliances, households’ energy generation, and the associated ICT solutions are included, the employment impact will probably greatly exceed that shown in Table 6.1. Secondly, estimation is made difficult by the fact that this field of industry is only taking its first steps, and its development prospects (e.g. 10 years from now) depend on numerous, as yet unknown, factors. The estimates presented in Table 6.1 are relatively conservative because of these uncertainties.

The demand for academic engineers and architects connected to sustainable urban and community structures will experience its biggest changes by the year 2030 by way of wide spread energy-efficient new construction and renovating of existing buildings. Improvement in energy efficiency calls for better planning and development of new concepts, especially in renovation. Furthermore, the significance of quality management during construction will receive more emphasis and there will be a need to develop energy-efficient and recycleable construction materials. These changes will lead to a situation where the demand for academic engineers and architects will slightly increase in planning of buildings, in management of construction projects, and in the development of new construction materials.

Concurrently with this, there will especially arise needs to develop traffic and energy-generation solutions in new and existing areas. In the case of sustainable urban and community structures, this means taking into account more diverse needs in urban planning and other planning tasks. This change will increase the demand especially for architects. It has been estimated that the energy efficiency of construction and the planning of areas will expand and that the demand for engineers will continue to increase up to the year 2050.
6.2 ENGINEER GRADUATES FROM POLYTECHNICS AND UNIVERSITIES OF APPLIED SCIENCES AND BACHELORS OF SCIENCE IN ARCHITECTURE

At the moment, some 12% of engineer graduates from Polytechnics and Universities of Applied Sciences and Bachelors of Science in Architecture hold positions in wood-based bioeconomy, about 1% work with smart grids, and 22% in tasks related to sustainable urban and community structures. All in all, there were approx. 110,000 engineer graduates from Polytechnics and Universities of Applied Sciences and Bachelors of Science in Architecture active in the working life in Finland at the end of 2010.

![Figure 6.2. The shares of engineer graduates from Polytechnics and Universities of Applied Sciences and Bachelors of Science in Architecture working in the fields of industry addressed in this report in comparison to all members of their professions in Finland at end of the year 2010](image)

Estimate of engineer graduates from Polytechnics and Universities of Applied Sciences and Bachelors of Science in Architecture currently holding positions in wood-based bioeconomy, smart grids, and sustainable urban and community structures, and of the future needs in these fields is presented in Table 6.2.

<table>
<thead>
<tr>
<th>Engineers 2010</th>
<th>Estimate for 2030</th>
<th>Estimate for 2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood-based bioeconomy</td>
<td>13 200</td>
<td>15 500</td>
</tr>
<tr>
<td>Smart grids</td>
<td>1 000</td>
<td>4 000</td>
</tr>
<tr>
<td>Sustainable urban and community structures</td>
<td>24 500</td>
<td>26 500</td>
</tr>
<tr>
<td>Others</td>
<td>71 600</td>
<td>28 500</td>
</tr>
<tr>
<td>Total</td>
<td>110 300</td>
<td>110 300</td>
</tr>
</tbody>
</table>

Table 6.2. Estimate of engineer graduates from Polytechnics and Universities of Applied Sciences and Bachelors of Science in Architecture currently holding positions in wood-based bioeconomy, smart grids, and sustainable urban and community structures, and of the future needs in these fields.

As regards wood-based bioeconomy, the growth in demand for engineers in 2030 is explained by the growth in demand for engineering expertise related to new biomaterials and bioproducts, wood construction, bioenergy, biofuels, and biomass procurement and logistics. It is estimated that the
demand for engineer graduates from Polytechnics and Universities of Applied Sciences will increase especially in various planning tasks in wood construction, in the wood-products industry related to it, and in the procurement of biomass and in the distributed generation of bioenergy.

In the field of smart grids, the need for engineer graduates from Polytechnics and Universities of Applied Sciences may increase even more markedly than the need for academic engineers. It is currently believed that this need will stay continuously a little higher than the need for academic engineers in the respective field. At the back of development there is a rapid increase in work such as basic planning and construction of grids, in work supporting grid management, and in engineers’ work related to smart homes and distributed electricity generation. Polytechnics and Universities of Applied Sciences provide more appropriate degrees than universities for these and other work related to smart grids.

As regards the demand for engineer graduates from Polytechnics and Universities of Applied Sciences from the field of sustainable urban and community structures, the biggest changes are likely to take place mainly in the same fields is expected to happen in the demand for academic engineers and architects. It is estimated that the demand for engineer graduates from Polytechnics and Universities of Applied Sciences will grow especially in building planning and management of construction projects, and in new and renovation construction. The growth of demand in district planning will be less.
7 SUMMARY

Significant change trends are apparent in all of the examined fields and their development will be powerful. The expertise needs of the future and the prospects of employment need to be identified now in order that we might be able to prepare for them. Engineers are significant actors in all of the examined fields, but other actors are also needed, and the task interfaces of engineers are bound to change. At the same time, the traditional boundaries of industries or fields of work will also undergo changes.

This development path will change the structures of society and decision-making, and it will also significantly impact on engineers’ expertise demands, on the organisational structures of employers companies and organisations, operating cultures, and values. For example: The branches of industry of traditional large companies, e.g. forest industries and energy industry, give birth to networks of smaller technology and service-provider companies in new areas. As the expertise needs change, as efficiency demands become more powerful, and as competition increases, private-sector actors will replace public-sector actors. The ageing of the “baby boomer” generation will accelerate these changes.

The growth in the need for the climate-friendly solutions will have the effect of increasing the demand for engineers’ expertise (Fig. 7.1). Demand will lead to expanding the business related to new solutions and thereby enable significant emissions reductions in the future. The demand for engineer’s expertise will increase well into the future as a result of the global need for new climate-friendly solutions. At the same time, the societal impact of engineers’ work and their expertise will also expand in partly enabling the resolving of the climate issue.

Figure 7.1. The growth in the need for climate-friendly solutions will increase the demand for the associated engineering expertise and lead to the expansion of the associated business, and enable significant emissions reductions

There are grounds for assuming that the growth of sustainable technology in Finland is close to the maximum of the international growth estimate of 10–30%. Significant drivers in this are technological development, changes in consumers’ values and political control, which all, for example, promote the role of conserving energy solutions in connection with future investments. The scale of this change is among the biggest in the history of the world… it is comparable to the consequences of industrialisation and digitalisation. It can be stated with a fair amount of certainty that every engineer will be impacted in one way or another. The breakthrough by new Finnish companies to the spearhead of international development, on the global markets as well, may well lead to unprec-
edented demand for Finnish engineering expertise. However, companies throughout the world are keenly interested in the sustainable technology market, and the number of actors is growing continuously globally as well.
8 SOURCES


2 Virtanen, E. et al. Viestintätteknologian ja palveluiden sähköistämisen päästövaikutukset, Liikenne- ja viestintäministeriö, 2010

3 ERA 17 – Energiaviisaan rakennetun ympäristön aika 2017, Ympäristöministeriö, Sitra ja Tekes, 2010


5 Sarvaranta, A. Älykkäät sähköverkot - Selvitys älykkäistä sähköverkoista ja niiden kehityksestä Euroopan unionissa ja Suomessa, Energiateollisuus, 2010
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.

As the Finnish contribution to the engineering associations’ international Future Climate – Engineering Solutions project the leading engineering associations in Finland, Academic Engineers and Architects in Finland 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 down 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 required level.

The climate plan’s part dealing with energy generation and consumption and the resultant emissions was drawn up in connection with the first stage of the Future Climate project in 2008 – 2009. The information of the first part was updated and the climate plan was expanded to include industry-specific assessments at the second stage of the project. The second part of Engineering Associations’ National Climate Plan for Finland takes a closer look at three fields – wood-based bioeconomy, smart grids, and sustainable urban and community structures – and at their future trends and changes in know-how needs and employment effects.

The international project involves using national plans as the basis for preparing engineering associations’ 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 December 2011.