INTERNATIONAL ENERGY AGENCY

Energy Policies of IEA Countries

FINLAND

2007 Review

OECD

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Faced with considerable challenges related to its geography and size, Finland's sound energy policies do much to overcome its situation. The country leverages its small market where it can – such as by adopting or harmonising with EU directives and policies. To counter its relative isolation, Finland strengthened its position by becoming part of the larger Nordic electricity market and enhancing energy linkages. At the core, however, the country ensures energy security by relying on transparency and sound market signals to investors and customers, as well as by making good use of domestic sources of biomass and nuclear.

As Finland continues to refine and enhance its energy policy, there are some areas that warrant special attention. As nearly all fossil fuels are imported and all natural gas comes through a single interconnection, the government should continue to explore ways to diversify import sources and routes. The new nuclear power plant currently being built – the first in a liberalised market – will help safeguard energy security, though the construction delays necessitate continued monitoring. Subsidies for peat, a fuel in abundance in Finland, should be reconsidered, as they are unlikely to enhance energy security. On the other hand, the government should continue to explore ways to expand new renewables, building on the current stock of biomass and hydro.

This book takes an in-depth look at Finland's energy policy today and, through comparisons with good examples in other IEA countries, provides critiques and recommendations for improvements to guide the country towards a sustainable energy future. While the review provides comprehensive coverage of all topics, this thematic report highlights energy efficiency and energy R&D.

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-seven of the OECD thirty member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To promote international collaboration on energy technology.
- To assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. Poland is expected to become a member in 2008. The European Commission also participates in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.
The European Commission takes part in the work of the OECD.

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EXECUTIVE SUMMARY

A small, somewhat isolated country, Finland takes a balanced view of its energy policy, taking advantage of its situation wherever possible. Where it can leverage its location and small size it does so. For example, it makes straightforward use of European Union directives and policies, without adding too many extra layers of regulations that could undermine the effectiveness of continent-wide policies. A small electricity market by itself, the country makes extensive use of gains from trade with its neighbours, not only as part of the well-functioning Nordic electricity market, but also with connections to Russia and the Baltics.

Its small size and isolation bring challenges as well, and the government works to address them in a balanced and cost-effective manner. The greatest of these challenges may be energy supply security – its very high import dependence in general and its strong reliance on one import source in particular. To balance the lack of import diversity, the country has high domestic diversity, drawing its supply from many different sources, including domestic sources – namely nuclear, biomass and hydro. Finland, like most IEA countries, also faces the challenge of rising greenhouse gas emissions, the level of which is much above its Kyoto Protocol target for the coming compliance period, and the country will struggle to meet its commitment. Here, again, the country has taken a pragmatic approach. It has taken as much advantage of domestic and international trading as possible, allowing it to lower its own cost of compliance, as well as driving international development of a market for carbon emissions. This helps lay the foundation for a global price for carbon and a cost-effective and comprehensive means for addressing climate change.

While Finland's energy policies are generally advanced, balanced and sound, scope exists for further improvement – as in all countries. Three areas can be given particular attention. The first is supply security. Continued government policies are needed to address this challenge, and we urge a somewhat more diverse and long-term approach. The remaining two key areas are energy efficiency and R&D, the two recurring themes of this report – arenas where longer-term policies can benefit the country's energy situation. Investments and policy enhancements in both of these areas help to improve energy security as well. While they are discussed in separate sections, these topics should all be viewed as intertwined and integrated parts of sound energy policy. Overall, the main theme of the recommendations of this report is that while the government generally has both a balanced perspective and balanced policies, a longer-term approach would be beneficial, bringing

sustainable gains in energy policy. While the report addresses energy policies comprehensively, the following sections highlight these three topics.

SECURITY OF SUPPLY

Finland's vulnerability due to its heavy reliance on imports from a narrow set of sources is well understood. The government is working on all fronts to reduce this vulnerability. With respect to natural gas, supply security is based on alternative fuels. Large natural gas users need to have ready access to an alternative energy source, usually fuel oil, and domestic customers without the ability to switch fuels have their supply secured by a propane-air production plant. This is a sound first-order security measure.

The market is currently considering alternative supply sources and routes, in particular a natural gas pipeline from the Baltics that, in addition to linking Finland to the pan-European gas network, would also give Finland access to storage. Furthermore, small-scale liquefied natural gas import options exist. We urge the government to continue to investigate these and other possibilities. The government should ensure that there are no undue domestic regulatory barriers to developing cost-effective gas import options.

Another means of reducing supply vulnerabilities is to enhance domestic sources of energy. The government is actively working to do this. Most notably, a new nuclear unit is under construction at Olkiluoto, scheduled to come on line in 2011 – the first new nuclear plant in a European IEA country in eight years and the first one to be built in a liberalised market. The plant is being built without distortionary Finnish government subsidies and will greatly enhance supply security. Its financing can also be a model for projects in other countries, especially countries with large energy-intensive industries. Further enhancing the framework for nuclear power in Finland is that the government has already has made a decision on a high-level radioactive waste repository – a unique and very positive situation. The long-term planning and commitment to keeping to the government-approved plan is commendable, underpinning long-term support for nuclear power in the country. Finland was able to reach this conclusion through a transparent process that involved consulting with and involving the public and other stakeholders, and then took a clear decision and carried it through.

One cause for some concern with respect to the new nuclear plant is the stopgap peak power supply arrangement in place until 2011. While we understand the concern about delays at Olkiluoto negatively impacting electricity supply security – as well as the difficulty in developing a comprehensive market-based measure within Nord Pool – the measure in place may undermine long-term security as it could discourage stable investment by the private sector.

Finland's biomass resources contribute significantly to the country's supply security in a cost-effective manner, particularly as they are typically used in the context of very efficient combined heat and power. Enhanced demand for biomass raw material will place pressure on this industry; the government should continue to maintain a balanced and realistic vision for the country's biomass resources. Biomass has traditionally been the focus of Finland's renewable energy portfolio. New research suggests that greater scope exists for cost-effective deployment of other renewables such as wind power. We urge the country to develop cost-effective, market-based means to ensure that these technologies can make a sustainable contribution to Finland's energy supply mix and energy security.

Turning to another domestic resource, peat, the new premium tariff that is provided raises concerns. While peat does diversify the country's domestic energy supply, it works at cross-purposes with another of the country's goals, namely environmental sustainability. The premium tariff is designed to directly counter the effect of the European Union's emissions trading scheme (EU-ETS), a policy designed to create a price signal for carbon. The premium tariff removes the incentive to move away from carbon-intensive fuels. Given the negative consequences of the tariff, we are pleased to see that it is only a temporary measure and urge the government to ensure that it is not extended past its scheduled end date.

ENERGY EFFICIENCY

While supply-side measures are often the first-order response to supply vulnerabilities, energy efficiency provides more sustainable and less costly supply security by eliminating the demand itself. Furthermore, it has the added benefit of reducing greenhouse gas emissions, thereby enhancing environmental protection. Finland already has many positive attributes with respect to energy efficiency, and the government has put in place many sound policies. For example, in addition to making good use of combined heat and power (CHP) – a very efficient energy technology – voluntary agreements are in place to further improve the already good efficiency levels of Finland's industry, and other sectors of its economy. Nonetheless, there are measures Finland can take to improve its energy efficiency that will enhance its commitment to the "three Es" of good energy policy: energy security, environmental sustainability and economic efficiency.

One key area where gains in efficiency can be made is the building sector. Finland's building codes are already quite high compared to other IEA countries, but there is further room for improvement. Not only can the standards be raised, but the building code mechanism can also be enhanced, creating room for higher standards, but also greater flexibility for builders. While the country already has a building envelope standard in place, Finland

might look to Sweden, where component requirements are complemented by a comprehensive energy performance standard that exceeds the component standards. This performance standard sets an absolute maximum for a building's energy consumption, but leaves it up to the market to decide how to achieve the standard. In the longer term, efforts to move the market towards so-called passive houses should be considered as they have energy requirements 50% to 70% below those of traditional houses but still provide the same level of comfort.

The transport sector also gives an opportunity for sustainable reductions in energy demand and in this arena the government is taking strong action. While the European Union is currently developing a comprehensive approach to transport efficiency, Finland has recently acted to improve its domestic policies, particularly important as the average carbon dioxide emissions from Finland's transport fleet are higher than Europe's average. The new taxation regime will not only create greater incentives for customers to purchase more fuel-efficient vehicles, but will also stimulate faster turnover of the vehicle stock. This will help reduce emissions of regional air pollutants. This flexible, market-based policy, to begin implementation in early 2008, is a model for other countries. To complement it, the government should continue to pursue other policies that encourage mode shifting, more efficient driving behaviour and more fuel-efficient vehicles.

While it takes longer to see the benefits of policies in the transport and building sectors than other actions to reduce CO_2 emissions and improve efficiency – not to mention that the results are more complex to achieve and harder to monitor because of the diverse set of factors and actors involved in the process – the significant and sustainable benefits they provide are worth the long-term commitment.

ENERGY R&D

Though a small country, Finland is a leader in energy R&D, leveraging its small size as it does in other energy arenas. The country has stable funding for R&D, strong national and regional funding organisations – particularly Tekes, the Technical Research Centre of Finland (VTT) and the Academy of Finland – and strong collaboration with industry. Perhaps most critical is its high level of funding on a per-GDP basis. When nuclear R&D is excluded, Finland's government R&D spending is higher than that of Japan and the United States on a per-GDP basis. Because of its small funding portfolio, the country rarely invests in research without matching funds from the private sector. It also places greater attention on late-stage development in order to avoid the "valley of death" that makes it difficult to bring technologies the last step – to market. Finally, the government makes ample use of international

collaboration, one of the best means of increasing the value of smaller levels of research funding.

Opportunity exists for marginal improvements in Finland's R&D, the most important of which is to provide clearer guidance to the R&D community about its priorities. The government gives the R&D community great scope to determine the energy R&D agenda. While this is a good approach in practice and over the short term, there is room for a greater government role. Without sacrificing research independence and flexibility, the government might provide clearer top-down guidance for long-term research priorities that are explicitly linked to overall energy priorities. This would be a good complement to the research priorities of the private sector, which are those technologies that are likely to develop more quickly and be competitive in the market.

We also urge continued action to maintain expertise in the nuclear industry. As nuclear power has stalled recently in some neighbouring countries, expertise has diminished. Finland should draw on its new construction of Olkiluoto, collaborating with universities and academia, to maintain and possibly strengthen comprehensive education and training in the field. Finland is already a leader in biomass research; the government should keep focus on maintaining this expertise, particularly for Finland-specific research areas, in light of the growing international focus.

KEY RECOMMENDATIONS

The government of Finland should:

- *Continue to address energy security concerns in a comprehensive and sustainable manner, placing focus not only on import security, but also on domestic supply diversity, new renewables and energy efficiency.*
- *Continue building on efforts to enhance longer-term policies that encourage energy efficiency.*
- *Give more top-down, strategic guidance to the energy R&D community on long-term energy policy priorities.*

Figure 1

Map of Finland

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.
Source: IEA.

GENERAL ENERGY POLICY

Though somewhat isolated from the larger European continent, Finland's energy policies are well integrated with those of Europe. In fact, much of its energy policy stems from the European Union's growing energy policy framework. Its energy markets are largely liberalised, with the electricity market well integrated with the competitive Nordic market, Nord Pool. On the other hand, the country's gas market is physically linked only with Russia, which supplies all its gas. With a general lack of domestic resources – apart from bioenergy and nuclear power – energy security is a high priority for Finland's energy policy.

COUNTRY OVERVIEW

With more than 180 000 lakes, coniferous forests covering much of its land, most of the territory situated above 60 degrees northern latitude and over one-third of the country above the Arctic Circle, Finland is a largely rural and uninhabited country, apart from the well-populated southern tip (see Figure 1). Only 6% of the country is arable land and approximately two-thirds is covered with forests. It is a mostly low country, with rolling plains. Given its geographic location, it has a cold climate, but this is moderated by the North Atlantic current. The country has long, cold winters and short, warm summers. Despite its relatively mild climate in the south, the country's 1 250 km of coastline are typically icebound in late winter, including its southern ports, requiring icebreakers to clear port lanes. Finland's longest border is its 1 340-km eastern border with Russia. It also shares a 614-km border with Sweden and a 727-km border with Norway.

Finland has a population of 5.2 million. The largest city, the capital city of Helsinki, has 560 000 inhabitants; the Helsinki metropolitan area, including Espoo (population 228 000) and Vantaa (population 185 000), has about 1 million. The other major city is Tampere, also in the southern part of the country, which has a population of 203 000. There continues to be a slow migration from northern to southern Finland. The country's total population has grown at an annual rate of 0.31% between 1992 and 2005, the sixth-lowest in IEA Europe and well below the OECD average of 0.75%.

Finland has a highly industrialised, free-market economy. Limited by its climate, the country has a relatively small agricultural sector. Its largest economic sector is manufacturing, particularly pulp and paper, metals, engineering, telecommunications and electronics. International trade is critical to Finland's economy; exports of goods and services represent almost

40% of GDP. Finland's GDP was USD 210 billion[1] in 2006, making it a relatively small European economy. Economic growth has been brisk in recent years, climbing from around 3% in 2004 and 2005 to 5.2% in 2006. Per-capita GDP ranks very high compared to most OECD and European Union countries and similarly to other northern countries. GDP per capita is just under EUR 30 000.

Finland – *Suomi* in Finnish – is a republic, with a unicameral legislature, the Parliament *(Eduskunta)*. The head of state, the President, is elected by popular vote for up to two six-year terms. The president appoints the prime minister and deputy prime minister from the majority party. Finland's parliamentary elections were held on 18 March 2007 and a new government was formed. Prime Minister Matti Vanhanen, of the Centre Party, ended the previous coalition with the Social Democrats and formed a new government with the centre-right National Coalition Party. The Centre Party and National Coalition have control of most ministries, while the Green Party and Swedish People's Party have control of a smaller number each. There are two ministers for the Ministry of Employment and the Economy, which handles most energy policy. The minister responsible for energy is from the Centre Party, which also holds the Ministry of the Environment. The next parliamentary elections will be held in 2011.

SUPPLY-DEMAND BALANCE

SUPPLY

Finland's total primary energy supply (TPES) was 35 million tonnes of oil equivalent (Mtoe) in 2005, an increase of 6% from 2000 and 18% from 1995 (see Table 1). Finland's overall fuel mix is relatively well diversified, though oil makes up the largest share of the total, over 30%. Finland has a very high share of biomass in its fuel mix. At 20%, it is the highest in the IEA and well above the IEA average of just over 5%. Nuclear makes up 17%, the sixth-highest of the 15 IEA countries with nuclear in their fuel mix. Natural gas makes up 10% and, combined, coal and peat make up 14%. Finland is one of only three IEA countries that have peat in their fuel mix. At 4.7% of TPES, it is just slightly below the 5% share in Ireland. While its neighbours, Norway and Sweden, have 36% and 12% of hydro in their TPES respectively, Finland has only a 3% share – the lack of mountains generally limits hydro capacity compared to its neighbours. Together, geothermal, solar, wind and other renewables make up less than 0.3%.

1. On average in 2006, USD 1 = EUR 0.80 (EUR 1 = USD 1.25).

Table 1

Supply-Demand Balance, 2005

Unit: Mtoe	*Total*	*Oil*	*Biomass*[1]	*Nuclear*	*Natural gas*	*Coal (excluding peat)*	*Peat*	*Hydro*	*Solar, wind, etc.*	*Electricity and heat*
Supply										
Production	16.6	0.1	6.9	6.1	0.0	0.0	2.1	1.2	0.1	0.1
Imports (net of exports)	19.5	11.2	–0.1	0.0	3.6	3.4	0.0	0.0	0.0	1.5
Other	–1.1	–0.6	0.0	0.0	0.0	–0.1	–0.5	0.0	0.0	0.0
Total primary energy supply	35.0	10.7	6.8	6.1	3.6	3.3	1.6	1.2	0.1	1.5
Share	*100%*	*31%*	*20%*	*17%*	*10%*	*9%*	*5%*	*3%*	*0%*	*4%*
Demand										
Electricity and heat production[2]	6.1	0.4	2.3	6.1	2.5	2.0	1.4	1.2	0.1	–9.8
Industrial consumption[3]	12.5	2.4	3.4	0.0	0.8	0.7	0.2	0.0	0.0	5.0
Transportation	4.9	4.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Residential	4.9	0.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2
Other final consumption[4]	3.5	1.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.3
Other	3.1	1.4	0.0	0.0	0.2	0.6	0.0	0.0	0.0	0.8
Total consumption	35.0	10.7	6.8	6.1	3.6	3.3	1.6	1.2	0.1	1.5

1. includes industrial and municipal waste.

2. In this row, electricity and heat inputs are shown as positive numbers in the columns from oil to solar, wind, etc.; electricity and heat output is shown in the last column as a negative number; and the total column represents the transformation losses.

3. includes non-energy use.

4. includes commercial/public services, agriculture/forestry, fishing and non-specified.

Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007.

Apart from the fall in oil from two-thirds of supply in the 1970s to less than a third by the 1990s, and the rise of natural gas from a 3% share of TPES in the 1970s to 10% in the 1990s – a figure that has remained relatively constant – the relative shares of different fuels in Finland's TPES have not changed dramatically since the 1980s. Peat and nuclear were introduced into the fuel mix in the 1970s.

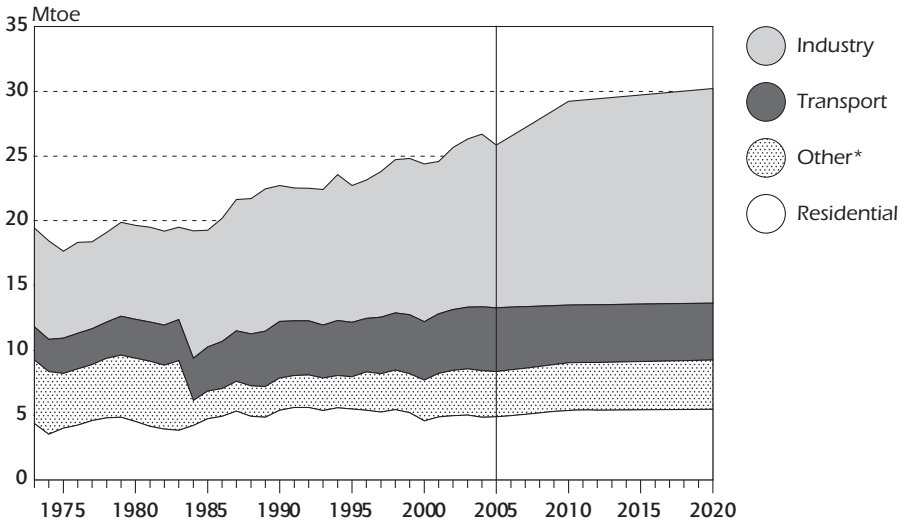
DEMAND

Total final consumption (TFC) of energy in Finland was 25.8 Mtoe in 2005. Nearly half of all consumption is in the industrial sector (including non-energy use). The transport and residential sectors each use just under 20% of TFC, with the remainder (14%) in commercial and other sectors. These shares have remained very steady since the mid-1980s.

The largest percentage increase in TFC by sector was in commercial and other sectors, which grew by over 11% over the last five years (see Figure 2). The transport sector had the next largest percentage increase, climbing by almost 10% in the last five years and 17.5% in the last ten years. No sector exhibited a decline in consumption. The industrial sector had the smallest increase of the past five years, 3%, but had an increase of almost 19% over the last ten years.

Figure 2

Total Final Consumption by Sector, 1973 to 2020



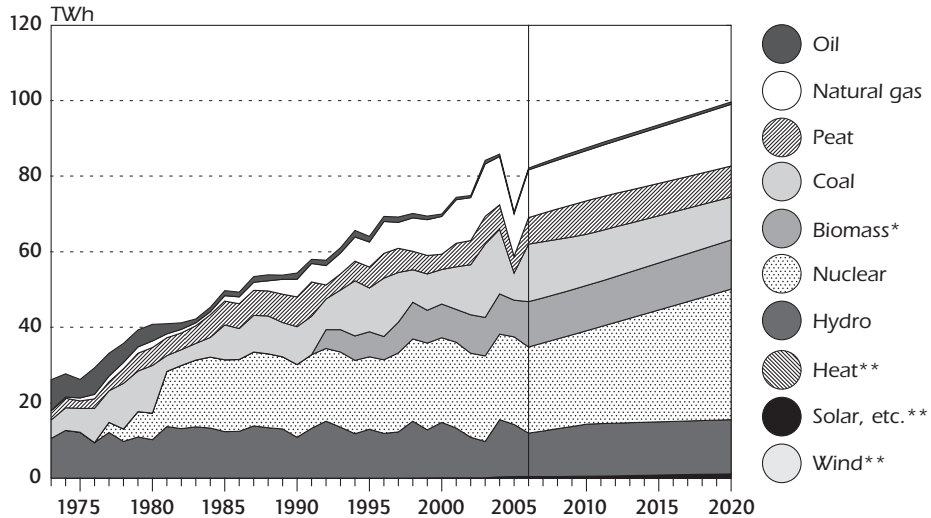
* includes commercial, public service, agricultural, fishing and other non-specified sectors.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

ELECTRICITY GENERATION

In 2005, over 70 terawatt-hours (TWh) of electricity were generated in Finland, a less than 1% increase from 2000. As shown in Figure 3, the largest share comes from nuclear, which provides one-third of total electricity. The next largest share comes from hydro, one-fifth – a relatively large share, though less than the 99% and 46% shares from its neighbours Norway and Sweden, respectively. Combined, coal and peat have a 17% share of generation, while natural gas has a 16% share. Generation can fluctuate strongly from year to year, owing to variable rainfall in the Nordic area. In a dry year, conventional fossil fuel power plants in Finland and Denmark make up for the reduction in hydropower production in Norway and Sweden. In a rainy year, Finland and Denmark become importers of hydropower.

Figure 3

Electricity Generation by Source, 1973 to 2020



* includes industrial and municipal waste. ** negligible.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

ENERGY FORECASTS AND SCENARIOS

Since 1990, mid-term scenario planning has been a central tool in Finnish energy and climate policy planning. In the 1990s, two mid-term energy strategies were formulated with the help of scenario analysis. Mid-term scenario analysis was also used in the preparation process for the first *National Energy and Climate Strategy* approved by the government in 2001.

An updated *National Energy and Climate Strategy* approved by the government in 2005 was prepared with the help of mid-term scenario analysis. (For more information, see the later section on key energy policies.)

The scenarios are prepared on a sectoral basis, including industry, buildings, transport, energy and agriculture, among others. The preparation of the scenarios is led by the Ministerial Working Group on Climate Change and Energy, which comprises eight ministries. The time horizon in the mid-term scenarios has been 20 to 25 years. When preparing the strategies, a business-as-usual scenario and a number of different policy scenarios are used, with due attention paid to the results of the sensitivity analyses.

In early 2007, the government began preparing its *Long-Term Climate and Energy Strategy*. The strategy will focus on 2050 and will be prepared on a sectoral basis under the Ministerial Working Group on Climate Change and Energy. The results of the updated long-term strategy are not yet available; it is expected that they will be given to Parliament in spring 2008. The preliminary version of the baseline scenario has been defined but it is not yet approved by the Ministerial Working Group. The baseline scenario is not a forecast, but a scenario in which energy consumption and greenhouse gas emissions have been estimated on the basis of current energy and climate policy measures. The results of the baseline scenario are used to estimate the magnitude of measures necessary to meet government commitments.

The government is also beginning work on an even longer-term energy and climate report. This report, which is separate from the strategy, has a focus on 2050 to 2100, but also on adaptation issues.

GOVERNMENT AND REGULATORY INSTITUTIONS

Since the last in-depth review in 2003, energy policy institutions have remained largely the same, with the exception of the expansion of responsibilities for the Energy Market Authority.

MINISTRY OF EMPLOYMENT AND THE ECONOMY

The lead government actor, the Ministry of Employment and the Economy (MEE), has the overall co-ordination and planning role in the energy policy field. (MEE was formerly the Ministry of Trade and Industry, MTI. On 1 January 2008, MEE was created by the merger of MTI, the Ministry of Labour and parts of the Ministry of Home Affairs.) More precisely, energy policy is the responsibility of MEE's Energy Department, which consists of the three substance divisions, the Energy Management and Nuclear Energy Division, the Energy Market Division and the Renewables and Energy

Efficiency Division. The Sustainable Development Project, which had been autonomous from these three divisions, is now part of the Renewables and Energy Efficiency Division. MEE also has specific implementing functions in the areas where no other suitable agencies are available. It works closely with other ministries, including those of Finance (taxation), the Environment (carbon dioxide emissions and other issues), Transport and Communications (transportation), Agriculture and Forestry (biofuels and sinks) and Foreign Affairs (international co-operation), as well as with a number of specialised agencies.

Under MEE, a number of special agencies have major responsibilities in the energy sector, as described below.

TEKES

The Finnish Funding Agency for Technology and Innovation, Tekes, finances research and development (R&D) projects for companies, research centres and universities. The funds are awarded from the state budget via MEE. Tekes also co-ordinates and finances Finland's participation in international technology initiatives.

VTT

The Technical Research Centre of Finland, VTT, has an energy research branch of more that 350 people. It focuses on new energy technologies, fuels and combustion, nuclear energy, engine technology and energy in transportation, the pulp and paper industry and energy systems.

MOTIVA OY

Motiva Oy (until December 2000, the Energy Information Centre for Energy Efficiency and Renewable Energy Sources) is an impartial and state-owned joint stock company with 30 employees. Its principal objective is the implementation of government policies on energy conservation and the promotion of renewable energy sources. In practice, Motiva Oy disseminates information, develops and markets energy audits as well as other energy management procedures and promotes energy-efficient technologies. Motiva Oy receives most of its funding from MEE.

ENERGY MARKET AUTHORITY

The Energy Market Authority (EMA) is an expert body subordinate to MEE. On 1 June 1995, it began operations as the Electricity Market Authority, at the same time as the Electricity Market Act took effect, opening stepwise the electricity market to competition. On 1 August 2000, the Electricity Market Authority became the EMA, at the same time as the Natural Gas Market Act took effect. In August 2004, the EMA also became the National Emissions Trading Authority in Finland. EMA currently employs 28 people.

The mission of the EMA is to supervise and promote the functioning of the electricity and natural gas markets, as well as to establish preconditions for emissions trading. The EMA's principal task in electricity and gas markets is to supervise the pricing of transmission, distribution and other network services. It monitors that pricing of network services produced by distribution and regional network operators and the national grid is reasonable and non-discriminatory. Supervision takes place on an *ex post* basis, case by case. Cases are brought up either through complaints, or on the initiative of the EMA.

The EMA also promotes efficient competition in the electricity and natural gas trade, by intervening in the terms and prices of the network services that are considered to restrict competition. It produces and publishes real-time information on the pricing of both electric energy and its distribution. In the future, the Energy Market Authority will start to publish the same types of information on the pricing of natural gas.

Electricity and natural gas network operations are subject to licence. The EMA grants network licences to organisations and utilities engaged in network operations, and building permits for constructing power lines with voltages of 110 kV and higher.

Since August 2004 the Energy Market Authority has also acted as the national emissions trading authority in Finland. The EMA grants emission permits, pursuant to which the installations have the right to emit CO_2. It also supervises the monitoring and reporting of emissions data and maintains the Emissions Trading Registry of Finland.

COMPETITION AUTHORITY

In addition to the EMA, the Finnish Competition Authority (formerly the Office of Free Competition) has regulatory responsibility in the energy sector, operating under MEE. It has the objective of protecting sound and effective economic competition and increasing economic efficiency by promoting competition and abolishing competition restraints (such as under the Act on Competition Restrictions).

SAFETY TECHNOLOGY AUTHORITY

Under the MEE, the Safety Technology Authority supervises the compliance of equipment with energy efficiency requirements.

RADIATION AND NUCLEAR SAFETY AUTHORITY (STUK)

The Radiation and Nuclear Safety Authority, STUK, under the Ministry of Social Affairs and Health, sets the regulations for the use of radiation and nuclear energy and supervises that they are followed. STUK is also an expert institute that carries out research on radiation and its effects, determines risks associated with radiation and monitors the radiation safety of the Finnish environment.

STATISTICS FINLAND

Statistics Finland operates as the national inventory unit for the evaluation and reporting of greenhouse gas emissions.

KEY ENERGY POLICIES

The government's primary energy- and climate-related policy objectives are based on its *National Energy and Climate Strategy*, which was elaborated and adopted in 2005. Under the strategy, Finland targets an additional 5% energy savings by 2015. At the same time, the government is committed to the EU energy efficiency goal (20% improvement by 2020) and its goal to prepare a new *Action Plan for Energy Efficiency* by the end of 2008. It has not yet been decided whether there will be a separate action plan or if it will be integrated in the new *Long-Term Climate and Energy Strategy*. Finland's goal for an additional 5% energy efficiency improvement from the 2005 strategy will be part of the overall EU goal and the details will be decided in the forthcoming action plan or long-term strategy.

Over the long term, the goal is to stabilise, and then reduce, total primary energy use in Finland. The specific objectives of the strategy are as follows:

- Development of the structure of energy production towards reduced greenhouse gas emissions.
- Promotion of free energy markets.
- Promotion of the efficient use of energy and energy conservation.

- Promotion of the use of bioenergy and other sources of indigenous energy.
- Maintaining high technological standards in the energy sector.
- Ensuring diversification of energy supply.
- Ensuring the secure supply of energy.

The Ministerial Working Group on Climate Change and Energy supervises the preparation of these strategies. The working group consists of six ministries, including MEE, the Ministry of the Environment, the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry, the Ministry for Foreign Affairs and the Ministry of Finance.

SECURITY OF SUPPLY

Finland is highly dependent on energy imports. All fossil fuels are imported and net imports of electricity can reach 15-20% of total consumption, depending on the rainfall in the Nordic area. Of particular concern are imports from Russia, which supplies all the country's gas, nearly all its oil and 10% of its electricity. Although the country currently only has import connections with Russia, the construction of a connection to Europe is a high priority.

COAL

There is no coal production in Finland; all coal is imported. Peat, a domestic resource, is used mainly for combined heat and power (CHP) production and covers about 6% of the total power production. A domestic resource, peat is given a feed-in tariff for reasons of security of supply. World coal market prices have spiked dramatically since the beginning of 2006, which will raise costs for Finland, but this is not likely to create any supply concerns.

OIL

There is no exploration or production of crude oil in Finland. Oil imports have been fully liberalised since July 1991. Of oil imports, 81% came from Russia, 10% from Denmark and the rest from the United Kingdom, Kazakhstan and Norway. Russia's contribution to Finland's crude oil imports has been rising for the past years. The largest oil company is Neste Oil, a majority state-owned company, whose activities cover the refining and marketing of oil, shipping and engineering services. Neste Oil owns the two national oil refineries (Porvoo and Naantali), with a combined refining capacity of about 14 million tonnes (Mt) a year (250 000 barrels per day), equivalent to about 150% of Finland's consumption. Most of Neste Oil's refined product is sold in the domestic market, though 60% of Finnish-produced gasoline and 35% of gas

oil are exported, with most going to the United States, Sweden, Denmark, Canada and Germany.

Finland is in full compliance with the IEA oil stockpiling requirement to hold 90 days of net oil imports. In fact, the country held 127 days of oil stocks on average in the first three quarters of 2007. Finland's stocks are held both in a public agency, the National Emergency Supply Agency (NESA), and by industry. Stocks held by industry are both for commercial and operational purposes, and to meet minimum stockholding requirements.

NATURAL GAS

Finland has no domestic sources of natural gas and has been importing all of its gas needs from Russia since 1974. Gasum Oy, which also owns and operates the transmission network, is currently the sole importer and wholesale supplier. Just under half of Finland's gas consumption is used in the industry sector, 43% in the power sector and 2% in the residential and commercial sectors. Security of gas supply is based on alternative fuels, usually fuel oil. Supplies to customers that can only use gas are secured by a propane-air production plant.[2]

Security of gas supply is a major concern given that Finland gets all of its supply from one company and through one pipeline. However, Finland's geographic isolation from the rest of Europe's gas transmission network may give it a higher degree of security of supply compared to others receiving their gas from Russia; there is no risk that a transit country can siphon gas *en route* to Finland. The incumbent company has no plans for diversifying gas sources. Government policy is to maintain large security stockpiles of oil and coal.

There is no gas storage in Finland. Major gas plants (both CHP and conventional power plants) have a legal obligation to have storage of reserve or alternative fuels, usually fuel oil, corresponding to three months of gas use. Industrial gas users have no obligation. Gas importers are obliged to maintain reserve fuel storages for small gas customers using less than 15 million cubic metres of gas per year. The National Emergency Supply Agency also keeps fuel oil storage to secure supplies to gas users.

2. A propane-air mixture can be used in natural gas networks without adjustments to individual burners. It is distributed via natural gas pipelines and can be injected in the distribution system after the city gate.

ELECTRICITY

Finland together with Sweden, Norway and Denmark make up the Nordic wholesale market, which is considered one of the most competitive electricity markets in the world. Given its heavy interconnections and trade with Nordic countries and on the Nord Pool power exchange, the traditional metric for supply security – reserve margin, or peak electricity demand as a share of maximum capacity – is not relevant. In general, Finland has sufficient domestic capacity and cross-border interconnection capacity. To further enhance supply security, a new 1 600-MW nuclear power plant, Olkiluoto 3, is being built, the first in a European IEA country in eight years and the first in a liberalised market, though it is now 18 months behind schedule.[3] Plans for two more units have been presented. Recently, a group of investors, led by Russians with access to some nuclear capacity, applied for a licence to build a 1 000-MW sub-sea transmission cable from Russia (St. Petersburg) to Finland; however, the application was rejected. A 350-MW, 105-km transmission line, the Estlink cable, which provides the first line linking the power grids of Estonia, Latvia and Lithuania with western European power supplies, went on line in January 2007 and should help ease any capacity concerns.

Under the Electricity Market Act, provisions permit the State to intervene in the market for reasons of security of supply. Under such conditions, the government can launch measures to build new capacity and make other procurements based on a call for tenders. It can also reject outage requests if it is estimated that electricity supply would not be sufficient to meet the demand during the period of the outage.

ENERGY TAXES AND SUBSIDIES

The structure and level of energy taxation have, with some exceptions, remained unaltered since 1997.

A basic tax and surtax, along with a security of supply fee, form the basis for energy taxation in Finland. These tax rates are detailed in Table 2. The basic tax is levied on mineral oil products and the surtax is levied on oil products, other fossil fuels and electricity. The surtax on fuels for transport and for heat production (but not for any other purposes) is based on the fuel's CO_2 emissions, at a rate of EUR 18.05 per tonne of CO_2. There is a special derogation for natural gas, which receives a 50% rebate. Fuels used in the

3. Construction of a second unit at Cernavoda in Romania started in March 2003 and went on line in October 2007. Construction was led by the Canadian company AECL with both the Italian company Ansaldo and the Romanian company SNN sharing the project management responsibilities.

production of electricity are exempted from all tax. Instead, electricity is taxed on the basis of consumption; there are separate tax categories for industrial and other uses. For CHP plants, fuels used for heat production are taxed. Finally, a tax refund system is in place for certain electricity production from renewables and energy-intensive industries.

Table 2

Tax Rates as of 1 January 2007

Product	*Basic tax*	*Surtax*	*Total*	*Security of supply fee*
Motor petrol (eurocents/L)				
Reformulated sulphur-free	53.85	4.23	58.08	0.68
Other grades	56.50	4.23	60.73	0.68
Diesel oil (eurocents/L)				
Sulphur-free	26.83	4.76	31.59	0.35
Other grades	29.48	4.76	34.24	0.35
Light fuel oil (eurocents/L)	1.93	4.78	6.71	0.35
Heavy fuel oil (eurocents/kg)	–	5.68	5.68	0.28
Coal (EUR/tonne)	–	43.52	43.52	1.18
Natural gas (eurocents/m^3 at 0°C)	–	1.82	1.82	0.084
Electricity (eurocents/kWh)				
Tax class I	–	0.73	0.73	0.013
Tax class II	–	0.22	0.22	0.013

Source: Ministry of Employment and the Economy.

POST-2005 TAX CHANGES TO ADDRESS IMPACTS FROM EMISSIONS TRADING

In general, the post-July 2005 tax changes were the result of an inter-ministerial working group set up in 2003 to evaluate and make its proposals for the use of energy taxation, energy production aid and other financial steering instruments in the context of the new emissions trading scheme, which took effect in 2005. The main conclusions were that the energy

taxation scheme then in place would still be needed for both energy policy and state finance reasons. However, some problems were anticipated, and it was determined that they should be alleviated by modifications to the energy taxation system. One finding was that emissions trading would impact the competitiveness of industry owing primarily to rising electricity prices, which could be compensated by lowering the electricity tax rate for industry.

Another finding was that, in some cases, difficulties could arise concerning the availability of wood raw material for certain parts of the forest industry, since emissions trading would increase the demand for wood used for energy purposes. It was recommended that tax subsidies for electricity produced by wood residues from industry be abolished both to lower the price increase of wood fuel and also because the subsidies were regarded as redundant.

Finally, it was determined that emissions trading would threaten the use of peat in energy production, especially in the production of condensing power, which could lead to serious employment problems in the peat branch and also weaken Finland's security of supply, given that peat is considered a major indigenous energy source. As a result, it was recommended to lower the tax on peat to improve its competitiveness.

The first step to implement these recommendations was the abolition of the tax on peat since 1 July 2005. At the same time, tax subsidies for peat in electricity production were discontinued. From the beginning of 2007, the electricity tax for industry (tax class II) was cut in half from 0.44 eurocents to 0.22 eurocents per kWh. Together with this tax, subsidies for electricity production by wood fuels (industrial residues such as bark, wood chips, saw dust and black liquor) and also by waste gases and waste heat from industry were discontinued. Other tax subsidies for renewable energy were continued in their previous form so that, for example, electricity produced from forest chips still receives subsidies along with wind power, small hydro, biogas and recycled fuel. In addition, a new tax refund system was introduced for agriculture in July 2006. Under this system, part of the taxes paid for fuel oil and electricity are refunded.

FUTURE TAXATION PLANS

The government is currently intending to raise energy taxes. The expected increase in tax revenue is about EUR 300 million per year, about 10% of the current revenue. The government has submitted a proposal to Parliament to raise energy taxes by an average of 9.8% in 2008. The highest tax is for energy products used mainly outside sectors covered by the emissions trading scheme. The tax on light fuel oil would increase by 23.2% and tax on electricity in class I by 18.8%. The tax on motor gasoline and diesel would rise

by 6.7% and 14.0% respectively. The government has also proposed to exempt biofuels from excise taxes when used for heating purposes or as motor fuel outside road transport.

CRITIQUE

Since the last in-depth review in 2003, Finland has made substantial progress in its energy policies, from a starting point that was already quite sound. In 2003, the country was already committed to the 3 Es of sound energy policy: energy security, environmental sustainability and economic efficiency. Light-handed regulation with vigorous oversight of energy markets was already in place. Its electricity market operated well, benefiting from the gains from trade made available by being part of the Nordic electricity market and Nord Pool, the region's electricity exchange. Finland had also already established a clear commitment to steady and transparent nuclear policy. Furthermore, biomass had a major role as a renewable resource. Adding to this list of 2003 achievements, there is now more for which Finland should be commended. Climate policy has been enhanced, taking a view to the first Kyoto commitment period. A new nuclear power plant is under construction to help ensure security of supply, the first nuclear plant built in a liberalised market and financed using an innovative structure without Finnish government subsidies. On similar lines, a new electricity grid connection to Estonia further enhances supply security. Overall, Finland's fuel mix is very well diversified, with four sources accounting for more than 15% each. Finally, R&D – which was already quite advanced, particularly for a small country – has continued to progress, underpinning the country's energy goals. In short, Finland's overall energy and environmental policies are sound and sustainable, and we are impressed with the continued progress the country has made. The country takes a very pragmatic policy approach, balancing energy security, environmental sustainability and economic efficiency better than many other IEA countries.

Its energy policy aims to address the many challenges Finland faces, including sustainable, competitive and secure provision of energy; climate change; the increasing import dependence; higher energy prices and increasing interdependence in energy infrastructures – challenges faced by many IEA member countries. Furthermore, much of its energy policy exists in the context of the larger EU framework. The many EU policies and measures in place strongly impact Finland's own energy and environmental policies.

We are pleased to note the link between energy policy goals and objectives, and policies and measures that address these goals. However, the government initiatives are generally focused on those that can bring short-term benefits. For example, in the area of climate change, much of the government's efforts are placed on the European Union's trading scheme for greenhouse gases, the

EU-ETS, a policy that brings clearly defined, short-term benefits. Less attention is paid to the longer term, such as to implementing policies and measures in the building and transport sectors, areas where consumption is growing. Efficiency improvements and emissions reductions in these sectors will require steady policy treatment as results are slower to emerge and less easy to quantify.

Finland is well-placed to put greater focus on longer-term policies and measures, as it is currently conducting the necessary long-term scenarios planning. The country is developing an energy strategy that looks to 2050. In fact, it is also beginning work on a strategy out until 2100, though strategy exercises that go this far out into the future are of uncertain usefulness. Long-term modelling efforts, such as Finland's projection to 2050, allow the government to understand the effects of various policy options, as well as already implemented national and international policies, in terms of their economic, environmental and social outcomes throughout their lifecycles. We commend the government's work in this area, as these long-term scenarios provide a guide to which policies and measures are necessary to achieve the desired long-term vision. We are also pleased to note that there is good co-ordination within the government in developing the scenarios and implementing the resulting energy and climate strategies.

To facilitate this longer view on energy and environmental policy, all stakeholders – including government, other authorities, industry, research, non-governmental organisations and the general public – need the ability to judge in a consistent and easily understandable way the risks and opportunities of different energy supply options, such as fossil, nuclear and renewables. In Finland, much work has already been done by the country's various research organisations, and the research is being integrated into government decision-making. We urge the government to continue this effort, putting emphasis on developing a consistent and co-ordinated framework for how to weigh various policy options, with a view to sustainability criteria being part of that analytical framework.

Finland relies on energy imports, much of which come from Russia, and this reliance will continue in the future. The government should continue to pursue policies that enhance security of oil, natural gas and electricity supply, in particular, in ways that do not unduly distort the market. Going forward, particular attention should be paid to the natural gas market's need for more import infrastructure, either through greater pipeline interconnection with Europe or through small-scale liquefied natural gas (LNG) imports. As regards electricity, rising demand is raising concerns about supply adequacy. While the new nuclear power plant at Olkiluoto will contribute to answering long-term electricity needs, attention should still be paid to policies to encourage new investment within Finland, efforts to increase and further diversify import capacity, and policies to reduce demand and create incentives for efficiency.

RECOMMENDATIONS

The government of Finland should:

- *Continue to build on the modelling framework in place to take a long-term view of energy and environmental policy so that options that may provide promising results – but are slower to develop – are adopted and implemented.*
- *Continue to ensure an integrated energy and environmental policy by developing a framework that allows all energy options to be evaluated according to a common set of criteria, including environmental, economic and sustainability criteria.*
- *Continue to ensure that long-term security of supply is a key component of all policy decisions, particularly with respect to enhancing the diversity of supply routes and suppliers, as well as demand-side measures.*

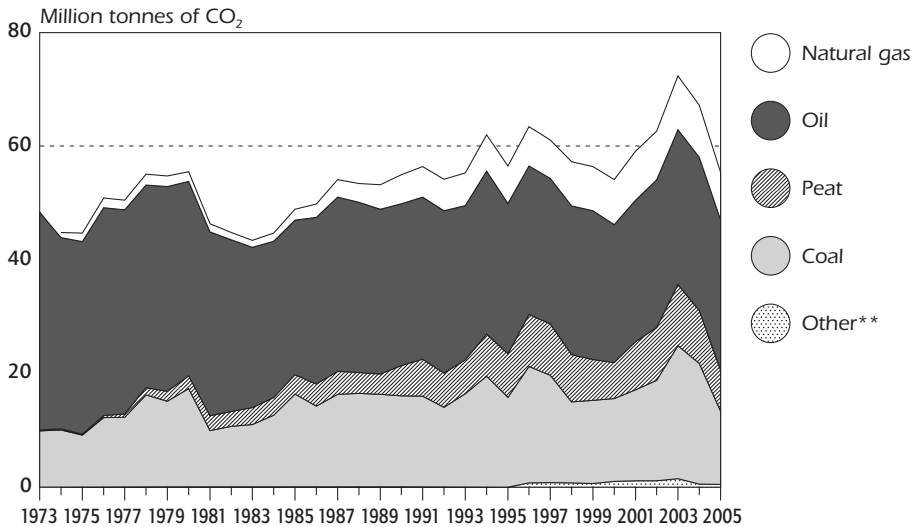
Under the Kyoto Protocol and the EU burden-sharing agreement, Finland has a target to stabilise its greenhouse gas emissions at their 1990 level. Currently, the country's emissions are about 20% above that target, so aggressive action is needed to comply with the Kyoto Protocol over the 2008-2012 commitment period. Finland intends to meet most of its target – over three-quarters – through reductions stemming from the EU emissions trading scheme (EU-ETS), which directly affects industrial and power sectors. It will also make extensive use of other international mechanisms, namely the project-based flexibility mechanisms, and is actively engaged in the credit procurement process.

CARBON DIOXIDE EMISSIONS PROFILE

As detailed in Table 3 and Figure 4, Finland's total carbon dioxide (CO_2) emissions from fuel combustion have risen by over 20% between 1990 and 2004. Emissions in 2005 were only 0.8% higher than their 1990 level, but this

Figure 4

CO_2 Emissions by Fuel*, 1973 to 2005



* estimated using the IPCC Sectoral Approach. ** includes industrial and municipal waste.
Source: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2007.

was due to very low coal emissions in 2005 that are not likely to occur again in the near future. While emissions from oil have declined, emissions from all other fuels – coal, peat, natural gas and non-renewable biomass – have grown. Emissions are expected to climb by a further 20% between 2005 and 2020, also because of increases from all fuels except for oil. When considering the country's full greenhouse gas emissions, the total was 86.0 $MtCO_2$-equivalent in 2003, over 20% more than in the base year 1990 and 11% above 2002 emissions. The energy sector is the most significant source of greenhouse gas emissions in Finland, with over 83% of total emissions.

Table 3

Energy CO_2 Emissions by Fuel*, 1970 to 2020

Unit: $MtCO_2$	*Oil*	*Coal*	*Peat*	*Natural gas*	*Biomass***	*Total*
1970	31.0	9.4	0.1	0.0	0.0	**40.4**
1980	34.2	17.3	2.3	1.7	0.0	**55.5**
1990	28.5	16.0	5.4	5.1	0.0	**55.0**
2000	24.3	14.6	6.3	8.0	1.0	**54.2**
2001	24.9	16.0	8.5	8.6	1.1	**59.2**
2002	26.0	17.7	9.3	8.6	1.1	**62.7**
2003	27.3	23.4	10.7	9.5	1.5	**72.4**
2004	27.0	21.3	9.3	9.2	0.5	**67.3**
2005	26.5	12.9	7.2	8.4	0.5	**55.4**
2010	25.3	24.9	8.0	10.8	0.5	**69.4**
2020	24.4	21.2	8.9	12.0	0.5	**66.9**
Change (1990-2005)	-7.1%	-19.5%	34.8%	65.3%	1 433.3%	**0.8%**
Change (1990-2004)	-5.1%	32.6%	73.6%	80.5%	1 600.0%	**22.3%**
Projected change (2005-2020)	-8.0%	63.9%	22.7%	43.6%	0.0%	**20.6%**
Average annual growth rate (1990-2000)	-1.6%	-1.0%	1.7%	4.6%	42.3%	**-0.2%**
Average annual growth rate (2000-2005)	1.7%	-2.4%	2.6%	1.1%	-14.7%	**0.5%**
Average annual growth rate (2005-2020)	-0.6%	3.3%	1.4%	2.4%	0.0%	**1.3%**

* estimated using the IPCC Sectoral Approach. ** includes industrial and municipal waste.
Sources: *CO_2 Emissions from Fuel Combustion*, IEA/OECD Paris, 2007 and country submission.

KYOTO TARGET

Finland ratified the United Nations Framework Convention on Climate Change (UNFCCC) in June 1992 and it entered into force in Finland at the beginning of August 1994. Finland also signed the Kyoto Protocol in April 1998 and ratified it in May 2002. As part of the agreement and the associated EU burden-sharing agreement, Finland has a target to stabilise its emissions to 1990 levels. (The EU as a whole agreed to reduce its annual emissions by 8% on average over the first commitment period, 2008 to 2012.) This is equal to a reduction of about 14 $MtCO_2$-eq from 2003 levels.

CLIMATE CHANGE POLICY

INSTITUTIONAL ARRANGEMENTS

The Ministry of the Environment is responsible for most environmental policy, assisted by the Finnish Environmental Institute. The Ministry of Employment and the Economy (MEE) is responsible for co-ordination of key climate policies, including the EU-ETS, the *National Energy and Climate Strategy* and communications with the UNFCCC, under its management of the government's Ministerial Working Group on Climate Change and Energy.

POLICIES AND OBJECTIVES

Climate policy objectives are codified in the *National Energy and Climate Strategy*, which was elaborated and adopted in 2005 (see Chapter 2). The climate-specific objectives of the strategy are the development of the structure of energy production towards reduced greenhouse gas emissions, the promotion of the efficient use of energy and energy conservation, the promotion of the use of bioenergy and other sources of indigenous energy, and ensuring diversification of energy supply.

MEASURES TO ACHIEVE EMISSIONS REDUCTIONS

In order to meet its target under the EU burden-sharing agreement, Finland must reduce its emissions by about 20% from current levels. To achieve this target, reductions will come from three main sources, namely domestic reductions from the EU emissions trading scheme (EU-ETS), domestic reductions from sectors outside the EU-ETS and international purchases of emission credits.

Table 4 provides a summary of how Finland intends to achieve its target. Row A shows the greenhouse gas average annual target for the first commitment period, 2008 to 2012. Row D shows the current estimate for average annual emissions during the first commitment period with current policies in place, but without the effects of the EU-ETS. The difference between these two values, 11.2 $MtCO_2$, is shown in row E and indicates that Finland must reduce its emissions by about 13% from what is expected without additional measures or the EU-ETS. This is less than the figure of 20%, Finland's current

Table 4

Overview of Kyoto Emissions Target and Measures to Achieve the Target

	Calculation of reduction needs	*Emissions ($MtCO_2$-eq)*
A	Target under Kyoto Protocol and EU burden-sharing agreement (average annual GHG emissions 2008-2012)	71.1
B	Total GHG emissions 2003 (excluding LULUCF emissions and removals)	85.7
C	Difference (negative number indicates a need to reduce emissions to achieve target)	–14.6
D	Average annual projected total GHG emissions 2008-2012 (using the "with measures" projection)	82.3
E	Difference (negative number indicates a need to reduce emissions to achieve target)	**–11.2**
	Calculation of measures to achieve necessary reductions	
F	EU-ETS*	–10.7
G	Additional policies and measures (other than emissions trading), including LULUCF	TBD**
H	Government purchase of Kyoto mechanisms	TBD**
I	Total reduction measures	**–11.2**

LULUCF = land use, land use change and forestry.

TBD = to be decided.

* The original government proposal for reductions in the Finnish EU-ETS sector was 8.7 $MtCO_2$-eq, but the EC decided to cut an additional 2 $MtCO_2$-eq.

** It has not yet been decided how the remaining 0.5 $MtCO_2$-eq will be allocated between additional domestic policies and measures and international purchases by the government.

Sources: *Finnish Proposal for a National Allocation Plan for Emission Allowances for the Years 2008-2012*, Annex 5, Finnish Ministerial Working Group on Climate Change and Energy, 29 September 2006; and country submission.

emissions above 1990 levels, because emissions are expected to decline somewhat in future years thanks to the commissioning of Olkiluoto 3, the new nuclear power plant. (In the longer run, emissions are expected to show an increasing trend.)

The second half of the table indicates from where the necessary 11.2 $MtCO_2$ reductions are expected to come. The lion's share of the total, about 10.7 $MtCO_2$-eq, will come from the EU-ETS. The remainder will come from domestic measures and government purchases of credits from the Kyoto mechanisms. The Kyoto mechanisms are joint implementation (JI), the clean development mechanism (CDM) and trade with other industrialised countries that have ratified the Kyoto Protocol. The exact distribution between domestic measures and credit purchases has not yet been determined.

Emissions trading

In September 2006, Finland submitted to the EU its proposed national allocation plan for emissions under the EU-ETS. It was accepted with some modifications in June 2007. The plan allocates 37.6 $MtCO_2$-eq per year to energy and industrial facilities during the Kyoto Protocol's first commitment period, 2 $MtCO_2$-eq less (about 5%) than initially proposed by Finland. This represents a 17% reduction from the 45.5 $MtCO_2$ allocation given from 2005 to 2007 and about 22% below the estimated business-as-usual emissions from these facilities. Finland is reserving 1.4 $MtCO_2$-eq per year for new entrants to energy and industrial sectors. The European Commission also reduced the percentage of credits deriving from project mechanisms that operators can use within the EU-ETS.

The specific allocations to facilities covered by the EU-ETS were approved by Parliament on 18 December 2007. In general, industrial facilities are granted emissions equivalent to 86-91% of their emissions from 1998 to 2002. Co-generation facilities and peaking and reserve power plants are granted emissions equivalent to 77% and 86% of their 1998 to 2002 emissions, respectively. The largest reductions come from the power sector; normal condensing power plants are granted emissions equivalent to 31% of their 2000 to 2003 emissions. Overall, this is a significant reduction from the emissions trading period of 2005 to 2007, as all facilities were then granted 94.5% of their emissions from their grandfathering period (generally 1998 to 2002, but 2000 to 2003 for conventional condensing power plants).

Domestic measures from the non-trading sector

Finland expects to gain quite small reductions from domestic measures outside the emissions trading sector in the short term. With respect to energy-related CO_2 emissions, the largest reductions are expected to come from an increased use of biofuels. Small reductions are expected to come

from changes in the building code, though these are not expected to reach their full effects until 2012, the final year of the Kyoto Protocol's first commitment period.

Finland has a CO_2 tax in place, which it was the first to introduce in 1990 (see Chapter 2). Besides its fiscal effects, this tax policy impacts CO_2 emissions.

International purchases

Purchases of emission credits from the international market can be used to offset domestic emissions above the Kyoto target. The three primary means of procuring international credits are described below:

- Under JI, projects in other developed countries that reduce emissions beyond business-as-usual levels can produce emissions reduction units (ERUs). This mechanism is one of the two so-called project-based Kyoto flexibility mechanisms.
- Under CDM, projects in developing countries can produce certified emissions reductions (CERs). This mechanism is one of the two so-called project-based Kyoto flexibility mechanisms.
- In addition to credits from JI/CDM, countries can purchase assigned amount units (AAUs) from other developed countries (or entities within the countries). AAUs are not created from particular projects; if an AAU is sold to another country, the sale increases the total emissions reduction the selling country must achieve by an equal amount.

Under the terms of the national allocation plan accepted by the European Commission, Finnish operators under the EU-ETS can rely on project-based mechanisms (*i.e.* JI and CDM) if they do not achieve their target through domestic actions for a maximum of 10% of Finland's annual greenhouse gas emissions cap (its so-called annual allocation), equivalent to about 3.8 $MtCO_2$-eq. This cap only applies to installations covered under the EU-ETS, but not to government purchases of credits from the Kyoto flexibility mechanisms. (This cap does not apply to the purchase of AAUs). In addition to the maximum 3.8 $MtCO_2$ that operators under the EU-ETS can purchase, the government intends to purchase not more than 2.4 $MtCO_2$.

The government has already begun to procure emission credits from the international market. It has emissions reduction purchase agreements (ERPAs) or investments in carbon funds for a total of 5.8 $MtCO_2$-eq under Kyoto flexibility mechanisms. As compliance with Kyoto is not measured in a particular year, these credits would apply to the entire 2008-2012 commitment period. They may be used to cover future commitments as well.

CRITIQUE

Environmentally, Finland is one of the most advanced countries among IEA member countries, particularly in terms of its extensive use of combined heat and power (CHP) facilities, high share of renewables in its total primary energy supply (TPES) and its general respect of the environment and sustainability in government affairs. In addition, in November 2005, the government developed a *National Energy and Climate Strategy* aimed at achieving its Kyoto Protocol target under the EU burden-sharing agreement. Finally, in the longer term, the new nuclear power plant, Olkiluoto 3, which is under construction, will contribute to reduced greenhouse gas emissions. We commend these achievements, and are particularly pleased to see environmental goals continue to be incorporated in overall energy policy in a comprehensive manner. Furthermore, there appears to be good co-ordination and collaboration across relevant ministries and actors.

The *National Energy and Climate Strategy* relies heavily on the EU-ETS and other international market-based mechanisms. However, no comparison of cost and potential analysis among the many different policies and options to reduce greenhouse gas emissions has been undertaken in Finland, including policies such as the Kyoto flexibility mechanisms; energy efficiency improvements in the industry, transport and residential sectors; development of renewables; and deployment of the EU-ETS. Such analyses are needed to ensure that the country is achieving its energy and environmental goals in the most cost-effective manner possible.

It is likely that the use of Kyoto flexibility mechanisms (JI and CDM) is one of the most cost-effective means of achieving greenhouse gas reductions, thereby lowering Finland's overall cost of complying with the Kyoto Protocol. Furthermore, use of these mechanisms, both by the private sector and the government itself, helps spur development of a global market for cost-effective CO_2 reductions. We are pleased to note that Finland relies on these mechanisms. Given the long lead time that these project-based mechanisms need to deliver reductions, we are also pleased to see the government take an active and early role in the process, both by having already procured some reductions and by setting aside the necessary funds to purchase the remainder. We urge the government to continue to monitor the process and funding levels to ensure that sufficient emission credits are procured in a timely manner, at the same time ensuring the appropriate, cost-effective balance with the use of domestic measures.

Finland's greenhouse gas emissions are very variable. Owing to the Nordic countries' high dependence on hydropower, greenhouse gas emissions change dramatically when the weather is wet or dry in the region. To ensure that

Finland meets its Kyoto target, the government should continue to take into account all possible climate scenarios, ensuring that sufficient options are available to meet climate change policy objectives under all hydro conditions.

RECOMMENDATIONS

The government of Finland should:

- *Implement a balanced approach towards achieving the Kyoto target on the basis of cost and potential analyses that compare all possible means of reducing CO_2 emissions.*
- *Continue the country's advanced role in the use of market-based mechanisms to cost-effectively reduce CO_2 emissions, including joint implementation and the clean development mechanism (JI/CDM).*
- *Ensure that sufficient options are available to meet climate change policy objectives under all scenarios for hydro conditions in the Nordic region.*

ENERGY EFFICIENCY

Though it has relatively high energy intensity compared to its neighbours – partly owing to more heavy industry – Finland has relatively high energy efficiency as well. Nevertheless, the country has room to improve its efficiency. Currently, the government's policies are based primarily on the various policies and measures in place at the EU level, complemented with broad-reaching voluntary agreements. Two areas for particular focus in the future are building and transport-sector efficiency. In addition, a comprehensive action plan should be developed that can bring together a coherent efficiency strategy for the longer term.

TRENDS IN ENERGY USE AND EFFICIENCY

Energy consumption has been growing in most sectors; only the residential sector has been largely flat. Total final consumption (TFC) of energy increased by almost a third between 1985 and 2005; it has risen by 6% since 2000. Industrial energy consumption has grown by almost 40% since 1985. Since 2000, however, it has only increased by 3%. Energy consumption in the transport sector has grown by 44% since 1985 and by 10% since 2000. Residential energy consumption has varied over the last 20 years, with a total increase since 1985 of just 3%.

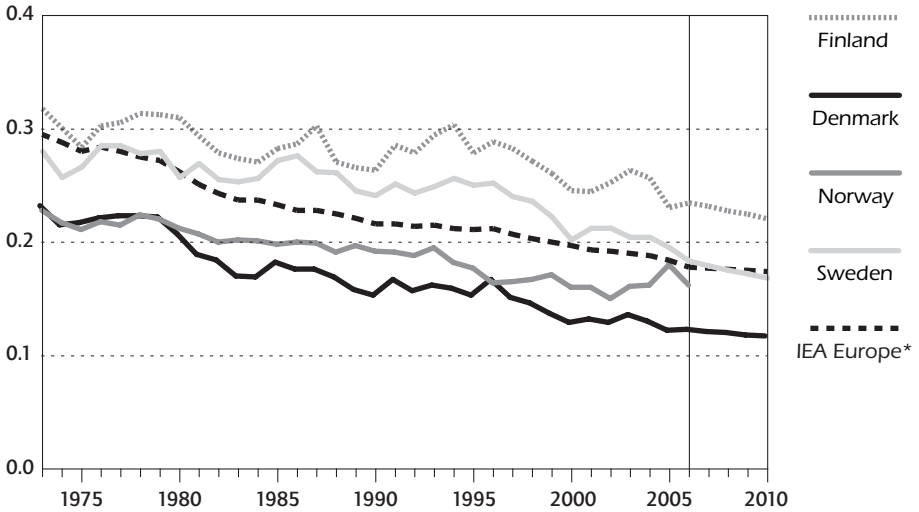
When compared to its Scandinavian neighbours as well as to the IEA Europe average, Finland's energy intensity is quite high, owing in part to high levels of energy-intensive industries such as paper and pulp and basic metals (see Figure 5). Overall, energy intensity has been declining over the last decade, falling by 23% between 1994 and 2006. Statistics Finland estimates that 48% of energy is used in industry, 22% for space heating, 17% for transportation and 13% for other uses such as by households, agriculture, forestry and the service sector.

Finland has an effective energy audit system, and can thus provide relatively detailed end-use indicators. Data from Statistics Finland indicate that the energy intensity of industry has been declining relatively steadily since 1990, falling by over 40% between 1990 and 2005. Looking more closely at some industries, data from the Odyssee database indicate that in terms of total final consumption per unit of value added, energy intensity of the metal industry has fallen by 33% between 1990 and 2002, while intensity fell by 17% in the chemical industry and by 0.48% in the pulp and paper industry. Over the same period, energy intensity in the non-metallic mineral products industry

Figure 5

Energy Intensity in Finland and in Other Selected IEA Countries, 1973 to 2010

(toe per thousand USD at 2000 prices and purchasing power parities)



* excludes Luxembourg and Norway throughout the series, as forecast data are not available for these countries.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007; *National Accounts of OECD Countries*, OECD Paris, 2007; and country submissions.

fell by 20%; by 47% in industrial installations that manufacture machinery, electrical equipment and vehicles; and by 37% in the food, beverage and tobacco industry. Energy intensity rose by 42% in the textile industry.

Turning to transport, signals indicate that energy intensity has been increasing. Total passenger-kilometres have been increasing steadily, tracking GDP growth. Data from Statistics Finland show that energy intensity in passenger cars (as measured in energy use per passenger-kilometre) fell by 12% between 1990 and 2004. Over the same period energy intensity has risen by 4% for buses and by 2% for rail. Domestic commercial aviation has shown a 33% decrease in energy intensity over the period. Taking a closer look at passenger vehicles, the fuel economy of newly registered cars has improved by 9% for gasoline cars and by 15% for diesel cars between 1993 and 2005, as reported by the Finnish Vehicle Administration (AKE). Somewhat surprisingly, this improvement in fuel economy has taken place as the engine size of newly purchased vehicles has increased dramatically (though some of this change is the result of changes in the data reporting methodology). Between 1990 and 2005, the number of new cars registered with small

engines (less than 1 300 cm^3) has fallen by 63%. Over the same period, the number of newly registered cars with medium-sized engines (between 1 300 and 2 000 cm^3) rose by 12%, while those with large engines (above 2 000 cm^3) more than doubled, rising by 159%.

In the building sector, energy intensity has also improved somewhat. The temperature-corrected specific heat consumption of households fell by 3% between 1995 and 2004. Looking at appliances, data from Motiva Oy on the Helsinki metropolitan area demonstrate that the sale of low-efficiency appliances (those rated below "A") has fallen dramatically over the last eight years since 1999. Whereas they made up over 82% of cold appliances[4] in 1999, low-efficiency appliances made up less than 8% in 2004. Over the same period, sale of A, A+, and A++ cold appliances grew from less than 18% of the market to over 92%.

POLICIES AND MEASURES

GOALS AND STRATEGIES

Finland's energy efficiency policies are primarily guided by two statements, namely the *Action Plan for Energy Efficiency*, which was issued in 2000 and updated in 2002, and the *National Energy and Climate Strategy*, which was first released in 2001 and updated most recently in 2005. In general, energy efficiency policy in Finland falls into four steering methods: *i*) legislation, regulations and guidelines; *ii*) financial mechanisms such as taxes and subsidies; *iii*) energy efficiency agreements with industry; and *iv*) education and communication. Under the *National Energy and Climate Strategy*, the target is an additional 5% energy savings by 2015 – decreasing energy use by 5% with new additional policy measures (compared with the expected situation in 2015 without these additional measures). In the long term, the goal is to stabilise, and then reduce, total primary energy use in Finland.

In the transport sector, efficiency policy is currently codified as part of the Ministry of Transport and Communications' *Environmental Guidelines for the Transport Sector until 2010*, which was released in 2005. The guidelines have nine key target areas, two of which have a direct relationship with energy efficiency: integration of environmental considerations into the preparation of transport systems; and reduction in greenhouse gas emissions and adaptation to climate change. The government has also elaborated a long-term strategy, *Traffic 2030*, which was adopted in April 2007 and prioritised reduction of CO_2 emissions and improvements in energy efficiency.

4. Cold appliances are those for which cooling is a primary function, such as refrigerators and air-conditioners.

Much of Finland's energy efficiency policy stems from the various EU directives relating to energy efficiency and conservation, in particular the directives on appliance labelling, on buildings, on energy services, on combined heat and power (CHP) and on ecodesign. Furthermore, the EU emissions trading scheme (EU-ETS) has an indirect, but strong effect on overall energy efficiency. In total, 14 separate directives or regulations inform Finnish energy efficiency policy. If additional measures beyond those already promulgated by the EU are necessary, Finland relies on voluntary actions, the development of technology and other innovative methods, subsidies for the introduction of new technologies and the use of renewables, and other regulations.

KEY ACTORS

The Ministry of Employment and the Economy (MEE) has the primary responsibility for energy efficiency policy, particularly the Renewables and Energy Efficiency Division. MEE also works closely with the Ministries of Finance, the Environment, and Transport and Communications. The Ministry of the Environment is responsible for building-sector legislation including, for example, energy efficiency requirements of buildings.

Motiva Oy, which was formed in 1993, is the primary implementing agency for energy efficiency in Finland. It is a state-owned joint stock company with 30 employees and an annual budget of EUR 4.4 million. Its mission is to promote energy efficiency, accelerate the uptake of renewable energy sources and promote efficient use of materials. It has a key role in the government's voluntary energy agreements. It prepares and markets the agreements, as well as develops tools and services to promote the execution of the agreements. It also conducts yearly sectoral reporting of results, along with developing and maintaining a monitoring system.

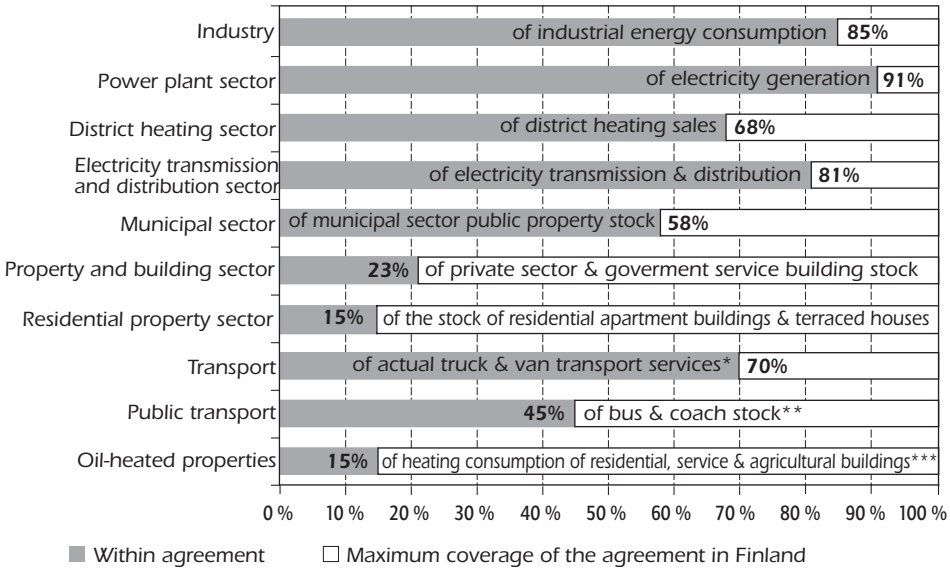
HORIZONTAL POLICIES AND MEASURES (INCLUDING INDUSTRY)

Voluntary agreements

Voluntary energy conservation agreements cover 60% of Finland's TFC and are a key mechanism in the country's overall energy efficiency policies. The eight agreements are with industry, the electricity generation sector, district heating, electricity transmission and distribution, municipalities, the property and building sector, housing properties, and the transport sector (see Figure 6). More than half of energy consumption covered by the agreements is in the industrial sector and about a third is in the energy sector.

Figure 6

Coverage of Energy Efficiency Agreements in Finland by Sector, End of 2005



* The energy efficiency programme for truck and van transport covers almost 70% of actual truck and van transport services.

** The public transport energy efficiency agreement covers 45% of bus and coach stock and all national railways local services, tram services and underground transport services.

*** The Höylä II energy efficiency programme for oil-heated properties covers more than 15% of heating energy consumption of residential, service and agricultural buildings.

Source: Motiva Oy.

Voluntary agreements are made between MEE and the association that represents the particular industry or sector. Companies and communities have also joined in the framework agreement signed by the industry association. In the municipal sector, each local authority or municipal federation signs its own agreement with MEE. Under the terms of the agreements, associations undertake to promote energy conservation and participation in the agreement scheme among their memberships. Companies and communities undertake to carry out energy audits or analyses, draw up an energy conservation plan and undertake to implement cost-effective conservation measures. The government provides subsidies for energy audits and analyses, and, under certain conditions, energy-saving investments. (With regard to housing properties, responsibility for audit subsidies and assistance for improvements in energy efficiency rests with the Ministry of the Environment.) The majority of energy conservation

agreements were scheduled to terminate at the end of 2005, but agreement parties decided to extend them by two years, until the new energy conservation agreement scheme is ready.

In 2004, MEE initiated an overall evaluation of its energy efficiency agreements in order to quantify their impacts and results and develop suggestions for modifications in the future. The study, released in 2006, reveals that the agreements are not only delivering the expected benefits, but exceeding the original expectations. At the launch of the agreements, the energy savings potential was estimated at 11 TWh at the end of 2005. The government and Motiva Oy estimated that about half of this potential could be realised by 2010. The 2006 evaluation estimates that 7.1 TWh per year was saved by 2005 under the existing agreements, almost 30% higher than the original estimate of savings through the agreements. To achieve these savings, between 1998 and 2005, the government spent EUR 12.1 million on energy audits, EUR 16.5 million on investment subsidies, and about EUR 4 million on administrative expenses. The agreement sectors invested an estimated EUR 350 million over this period to implement energy savings measures.

Energy audits

One of the cornerstones of the voluntary agreements is energy audits. The government seeks to drive cost-effective investments in energy efficiency by subsidising the costs of audits and helping to lower the information barrier. While MEE continues to subsidise up to 50% of the cost of energy audits for municipalities, the subsidy rate for industries and private services was reduced to 40% in 2002 in compliance with EU rules (see Table 5). Motiva Oy monitors the quality of the audits and provides feedback to auditors when necessary. In 2002, a more detailed set of execution and reporting guidelines was produced for the industrial energy analysis.

Energy service companies

Energy service companies (ESCOs) are specialist businesses that take responsibility for energy efficiency, including auditing, establishing efficiency plans, implementing the plans and financing the efforts on behalf of a client. They are often paid by taking a share of the client's energy savings realised through the ESCO's efforts. Motiva Oy is working to promote this type of service by registering ESCOs and providing information on them to both potential clients and service providers. The number of ESCOs registered with Motiva Oy has been increasing in recent years. Motiva Oy estimates that 15-25% of energy efficiency investments undertaken by industry under the voluntary agreements were executed through ESCOs.

Table 5

Number and Costs of Energy Audits, 1992 to 2006

Year	*Sector*	*Number of decisions*	*Number of buildings*	*Building volume*	*Industry*		*Audit costs*	*Subsidy*
				Million m³	*Heat and fuels TWh/year*	*Electricity TWh/year*	*Million EUR*	*Million EUR*
92-97	Public services	335	2 139	35.6			5.60	2.49
92-97	Private services	438	890	33.6			3.88	1.76
92-97	Industry	310	514		4.0	2.2	6.42	2.94
1992-97	**Total**	**1 083**	**3 543**	**69.2**	**4.0**	**2.2**	**15.90**	**7.19**
98	Public services	24	208	2.5			0.53	0.24
98	Private services	33	39	1.2			0.26	0.10
98	Industry	31	81		6.8	2.1	1.05	0.51
98	Power and heat	6	11				0.33	0.16
1998	**Total**	**94**	**339**	**3.8**	**6.8**	**2.1**	**2.17**	**1.02**
99	Public services	18	167	2.8			0.65	0.31
99	Private services	16	21	0.7			0.10	0.04
99	Industry	48	85		20.7	10.0	2.38	1.17
99	Power and heat	8	10				0.34	0.17
1999	**Total**	**90**	**283**	**3.5**	**20.7**	**10.0**	**3.46**	**1.69**
00	Public services	14	131	3.0			0.52	0.25
00	Private services	20	56	2.9			0.35	0.16
00	Industry	57	67		21.2	8.2	2.87	1.42
00	Power and heat	8	16				0.34	0.17
2000	**Total**	**99**	**270**	**5.9**	**21.2**	**8.2**	**4.08**	**2.00**

Table 5

Number and Costs of Energy Audits, 1992 to 2006

Year	*Sector*	*Number of decisions*	*Number of buildings*	*Building volume*	*Industry*		*Audit costs*	*Subsidy*
				Million m³	*Heat and fuels TWh/year*	*Electricity TWh/year*	*Million EUR*	*Million EUR*
01	Public services	29	250	4.5			0.92	0.45
01	Private services	26	112	4.8			0.61	0.29
01	Industry	40	57		3.3	1.9	1.71	0.85
01	Power and heat	13	49				0.64	0.32
2001	**Total**	**108**	**468**	**9.3**	**3.3**	**1.9**	**3.88**	**1.91**
02	Public services	47	280	4.8			0.85	0.42
02	Private services	45	251	11.4			1.26	0.51
02	Industry	49	86		4.5	3.1	2.02	0.81
02	Power and heat	2	3				0.03	0.01
2002	**Total**	**143**	**620**	**16.1**	**4.5**	**3.1**	**4.16**	**1.75**
03	Public services	30	137	2.1			0.46	0.23
03	Private services	48	122	6.4			0.69	0.28
03	Industry	49	57		6.2	3.3	2.62	1.05
03	Power and heat	10	21				0.37	0.15
2003	**Total**	**137**	**337**	**8.4**	**6.2**	**3.3**	**4.15**	**1.70**
04	Public services	45	242	4.1			0.88	0.44
04	Private services	17	54	3.1			0.35	0.14
04	Industry	55	69		7.8	1.4	2.21	0.88
04	Power and heat	5	6				0.20	0.08
2004	**Total**	**122**	**371**	**7.3**	**7.8**	**1.4**	**3.64**	**1.54**

Table 5

Number and Costs of Energy Audits, 1992 to 2006

Year	*Sector*	*Number of decisions*	*Number of buildings*	*Building volume*	*Industry*		*Audit costs*	*Subsidy*
				Million m³	*Heat and fuels TWh/year*	*Electricity TWh/year*	*Million EUR*	*Million EUR*
05	Public services	32	178	3.1			0.58	0.28
05	Private services	29	55	2.9			0.39	0.15
05	Industry	55	62		1.3	1.1	2.94	1.16
05	Power and heat	8	12				0.63	0.25
2005	**Total**	**124**	**307**	**6.0**	**1.3**	**1.1**	**4.53**	**1.85**
06	Public services	16	39	0.6			0.13	0.06
06	Private services	18	38	2.0			0.21	0.08
06	Industry	54	61		3.7	1.1	2.12	0.85
06	Power and heat	10	11				0.57	0.23
2006	**Total**	**98**	**149**	**2.7**	**3.7**	**1.1**	**3.03**	**1.22**
92-06	Public services	590	3 771	63.1			11.1	5.2
92-06	Private services	690	1 638	68.9			8.1	3.5
92-06	Industry	748	1 139		79.5	34.3	26.3	11.6
92-06	Power and heat	70	139				3.5	1.5
1992-2006	**Total**	**2 098**	**6 687**	**132.1**	**79.5**	**34.3**	**49.0**	**21.9**

Source: Motiva Oy.

Public information and advice

In recent years, Motiva Oy has been placing greater emphasis on information and communication with the public through print, radio and public events. One recent effort, the *Climate Change Communications Programme*, which was launched in 2002, seeks to raise awareness that changing personal behaviour can have an effect on climate change. Another programme focuses on driving behaviour and encouraging ecodriving. The *Energy-Efficient Home* campaign provides information to builders on how to build energy- and cost-efficient houses. Motiva Oy has also focused on education aimed at children and young people.

BUILDINGS

Finland has implemented the EU directive on the energy performance of buildings. Voluntary agreements with property owners also seek to improve the energy performance of buildings.

Building codes

Given its climate, Finland has one of the highest space heating needs in Europe. The country's thermal insulation ordinances were strengthened in October 2003 with the aim of reducing the energy consumption and CO_2 emissions associated with space heating. These strengthened ordinances are estimated to have improved insulation levels of new buildings by 20-30% as compared with the old 1985 regulations. The ordinances were further updated in June 2007 and apply to all new heated buildings, except some industrial buildings, greenhouses and holiday homes. They set reference and maximum U-values[5] for outer walls, floors and ceilings, and generally limit the window surface area to 15% of the floor area and 50% of the outer wall area. Builders can either choose to meet the maximum component U-values, or meet a comprehensive building envelope standard. The building envelope standard allows buildings to exceed the maximum component U-values by 20% if specific requirements are fulfilled for air-tightness and heat recovery (see below). The purpose of the 20% cushion for the building envelope is to provide some flexibility to builders to allow them not to meet all component standards, while still giving smaller builders the option to simply meet each specific component standard.

5. The U-value represents thermal transmittance, which describes how much energy passes through one m^2 of a construction by a difference of one degree in temperature. It is usually measured in watt (W) per degree Kelvin (K) per m^2.

In addition, the building ordinances set requirements on maximum heat loss for the whole building (the building envelope, ventilation and air-tightness). It is therefore possible to meet a lower standard if heat recovery is installed or particular values for air-tightness are met.[6]

A comparison of component and overall U-values in Finland from June 2007 and neighbouring countries with similar climates is shown in Table 6. Despite these increases in building standards, compared with

Table 6

Energy Efficiency Building Standards in Nordic Countries

	Component U-values				*Overall U-values*[1]	
	Ceiling	Wall	Floor	Windows	Overall	Average
Denmark[2]	0.15	0.20	0.12	1.5	0.77	0.77
Finland[3]	**0.15**	**0.24**	**0.15-0.24**	**1.4**	**0.91**	**1.01**
	0.18	0.29	0.29	1.7	1.10[4]	
Norway[3]	0.13	0.18	0.15	1.2	0.70	0.80
	0.18	0.22	0.18	1.6	0.90[5]	
Sweden	0.13	0.18	0.15	1.3	0.72	0.72

1. Overall U-values are calculated in order to compare across countries. It sums the U-values from the ceiling, wall and floor, and then adds 20% of the window value.

2. The values correspond to requirements for renovations; new buildings have lower component U-values, but a more stringent energy performance standard.

3. The two sets of values correspond to two different ways to calculate compliance, either based on U-values alone or an overall frame value with some maximum U-values.

4. This overall value results when the U-values are combined with heat recovery from exhaust air and meeting air-tightness requirements.

5. This overall value results when the U-values are combined with a maximum energy frame value for the whole building.

Source: Laustsen, Jens, "Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings", IEA working paper, forthcoming.

6. The additional values set for heat recovery and air-tightness are for the efficiency of heat recovery from exhaust air (annual efficiency of 30%) and the requirements for the air-tightness of the building (N_{50} = 4 1/h).

other nearby countries, building standards in Finland are not quite as stringent as those of its neighbours. Furthermore, given the 20% cushion for builders choosing the reference values, the U-values overstate the stringency of the standards.

Similarly, the October 2003 and June 2007 ordinances on indoor climate and ventilation updated the 1987 regulations. The new ordinances set requirements for the efficiency of the heat recovery from exhaust air. Motiva Oy launched a window energy rating system in the beginning of 2006. A pilot programme was carried out between May 2004 and December 2005.

Energy grants

Energy grants were provided from 2003 to 2005 by the Housing Fund of Finland (Valtion asuntorahasto ARA), which receives funding from the government and other sources. The total grant amount was determined in the state budget on a yearly basis. Since 2006, energy grants have been given directly from the state budget. Grants are distributed to municipalities for final disbursement to private entities. As discussed in the earlier section on energy audits, funding can be provided for up to 40% of energy audits and up to 10-15% of investments related to energy efficiency such as for insulation, windows, ventilation, heating systems (including renewables heating systems), connection to district heating, boilers, heat pumps and installation of apartment-specific water metering. Energy grants were given from 2003 to 2006 for residential buildings with a minimum of three flats. They were only given for measures recommended after energy audits or similar inspections.

Detached and semi-detached houses owned by a private person have been able to receive energy grants since the beginning of 2006. These grants are only given for the change of a heating system to one that uses renewable energy.

TRANSPORT SECTOR

In recent years, consumption of energy in the transport sector has been increasing; road consumption of oil has risen by over 9% since 2000 and by over 17% since 1995. Under its environmental guidelines for the transport sector and in conjunction with the climate strategy for the transport sector, the key measures to improve energy efficiency of the transport sector are the following:

- Sustainable transport system planning in conjunction with urban land use planning.
  - Promotion of public transport, cycling, walking and rail transport.
  - Investments in logistics, telematics and traffic management.
- Voluntary energy-saving agreements with traffic carriers.
  - Public transport carriers.
  - Van and truck drivers association.
- Ecodriving campaigns.
- EU agreement with car manufacturers and vehicle tax.

In general, the government has taken a light-handed approach to the transport sector, apart from implementing the EU directives related to transport; however, this will change somewhat with the new legislation. With respect to transport measures in place at the EU level, Finland has implemented the EU energy services directive and is in the process of complying with the new initiatives on ecolabelling, energy-efficient tyres and air-conditioning systems, for example. Finland is also working to implement the EU CO_2 and energy-savings strategies, though these have not yet been definitively set by the EU.

As shown in Table 7, approximately 85% of newly registered cars in Finland are gasoline-powered, with the remainder powered by diesel, a figure that has stayed relatively steady over the last decade. Registrations of both diesel- and gasoline-powered vehicles have continued to increase since 2000, though new registrations of gasoline-powered vehicles are down from the peak in 2003. The average CO_2 emissions of newly registered gasoline vehicles have fallen by over 5% over the last decade, with CO_2 emissions of diesel vehicles falling by over 3%. However, emissions of newly registered diesel vehicles have been increasing in the last five years. The target of the proposed EU CO_2 strategy is average vehicle emissions of 120 g CO_2 per km by 2012 for new cars, which is equivalent to a 25% reduction across the EU. A 33% reduction would be required in Finland, as its average new car emissions are 180 g CO_2 per km.

On 1 November 2007, the government announced that it will implement a revised vehicle taxation policy, affecting both the passenger car tax and the annual motor vehicle tax. As discussed more fully in Box 1, the revised tax rates will be based on the vehicle's CO_2 emissions, guiding consumers towards cars with lower CO_2 emissions while also encouraging faster turnover of older vehicle stock that will also help lower air pollutants such as nitrous oxides and particulates.

In addition to these measures, the government has implemented voluntary agreements with public transportation entities, as well as with the truck and van transport sector. It is also actively engaged in dissemination of

Table 7

Carbon Dioxide Emissions and Registrations of Vehicles, 1993 to 2006

	Gasoline		*Diesel*		*Gasoline and diesel*	
	CO_2 emissions (g/km)	Number of newly registered vehicles	CO_2 emissions (g/km)	Number of newly registered vehicles	CO_2 emissions (g/km)	Number of newly registered vehicles
1993	194.0	51 465	201.0	4 370	195.0	55 835
1994	195.0	63 455	196.0	3 745	195.0	67 200
1995	194.0	74 386	191.0	5 504	194.0	79 890
1996	189.0	82 878	182.0	12 949	188.0	95 827
1997	184.0	89 225	170.0	15 280	182.0	104 505
1998	181.0	106 025	165.0	19 725	179.0	125 750
1999	177.0	114 295	156.0	22 025	174.0	136 320
2000	183.0	108 273	159.0	26 330	174.0	134 603
2001	181.9	90 770	155.7	15 284	178.1	106 054
2002	180.0	97 999	159.3	15 261	177.2	113 260
2003	180.2	124 661	167.0	20 250	178.3	144 911
2004	182.0	120 422	168.0	19 909	180.0	140 331
2005	181.0	122 914	172.0	22 763	179.6	145 679
2006	179.3	*n.a.*	175.9	*n.a.*	180.0	145 679

n.a. = not available.
Source: Tampere University of Technology and Vehicle Administration (Finland).

information, such as on ecodriving and on the CO_2 emissions of on-sale vehicles, and in encouraging mode shifting from single passenger vehicles to walking and cycling through education and improvements in bike lanes in metropolitan areas.

Public transportation

As part of the November 2007 legislation, funding for public transportation in major urban centres will increase from 2009.

Box 1

Overview of New Vehicle Taxation Policy

In late 2007, the government proposed revisions to the car tax levied on passenger cars upon registration and to the annual vehicle tax levied on all registered vehicles. The revisions will set the tax rates relative to the carbon dioxide emissions resulting from the vehicle's specific consumption of fuel. On average, the revisions should cut the car tax by one-sixth. The change in car tax entered into force on 1 January 2008; the change to the annual vehicle tax is expected to take effect around 2010, though no firm date has been set.

Consumers could benefit from the staggered taxation by choosing a smaller car, the diesel version of a car or a variant which is more economic in fuel consumption. Because the tax regime will lower the annual vehicle tax rate levied on cars with lower emissions, the change is expected to encourage faster turnover of the vehicle stock, which will also have the effect of introducing cars with the latest technology and lower exhaust pollution emissions, such as nitrous oxides and particulates.

Source: Ministry of Transport and Communications, "Car tax and annual vehicle tax to be based on carbon dioxide emissions", press release 109/2007, 1 November 2007.

APPLIANCE STANDARDS AND LABELLING

The energy consumption labelling regulations convert the EU directives on labelling of household electric appliances into Finnish law. The law requires the retailers and manufactures of household appliances to attach labels on electric appliances containing information about the consumption of energy and other essential resources, guiding consumers to choose more energy-efficient appliances. The appliances included in the labelling scheme are refrigerators, freezers and their combinations; electric ovens; air-conditioners; dishwashers; lamps; and washing machines, tumble dryers and washer-dryers.

Appliances are classified in seven classes, from A to G, where class A is for the most energy-efficient appliances and class G for the least efficient ones. In July 2004, new A+ and A++ classes were introduced for appliances whose electricity consumption is at least 25% and 40%, respectively, smaller than that of equivalent consumption in a class A appliance.

The energy labels are supervised by TUKES, the Safety Technology Authority in Finland.

ELECTRICITY SECTOR

Finland makes extensive use of combined heat and power (CHP), in the form of both district heating sold to end-use customers and CHP facilities used in industrial facilities. The same diversity of fuels used in electricity is used in CHP (natural gas, coal, peat, wood and a small amount of oil as a backup fuel). The fuel used for district heating in southern Finland is primarily natural gas and coal at the coast; in the rest of Finland it is mainly peat and wood. In the forest industry, it is typically wood in several forms (sawdust, bark and black liquor), peat and natural gas.

The power capacity available during peak load periods for CHP in district heating is 2 790 MW, and 2 450 MW in industry (more than 40% of capacity combined during peak load). Industrial CHP produced 13.0 TWh of electricity in 2004, 11.8 TWh in 2005 and 13.1 TWh in 2006. Heat and electricity production from district heating facilities are detailed in Table 8.

Data for 2004 and 2005 indicate that while production of district heat and electricity declined over the one-year period, the number of customers and

Table 8

District Heating in Finland, 2004 and 2005

	2004	*2005*	*Change*
District heat production (GWh)	31 600	31 300	–1.0%
Net production of electricity in CHP production (GWh)	14 800	13 900	–6.3%
Fuel energy consumed (GWh)	54 300	52 800	–2.8%
District heat consumption (GWh)	29 500	29 300	–0.8%
of which share of dwelling houses	53%	56%	
Number of customers	97 300	101 800	4.6%
Connected heat load (MW)	15 400	15 600	1.0%
Building volume of customers (million m^3)	733	753	2.7%
of which share of dwelling houses	47%	47%	
Average selling price			
arithmetic average (EUR/MWh)	42.9	45.5	5.9%
weighted average	38.9	41.4	6.4%
Total length of district heating networks (km)	9 700	10 000	3.5%

Source: Finnish Energy Industries, "District Heating in Finland 2005".

volume of connections grew (see Table 8). Of new heating load, about 60% of the connected building volume was new buildings, while the rest was changing means of space heating, underscoring the continuing move away from oil for space heating.

Given the large CHP share in both power production (more than 40% of capacity during peak times) and district heat production (about 75%), the technology receives only modest support as it is generally very competitive. CHP receives a small tax subsidy. Excise taxes on the fuels in heat production from CHP are paid at 90% of the heat provided (whereas in non-CHP facilities fuels are taxed in full). Small biomass-fired CHP plants can receive a subsidy of up to 30% of the investment costs (normally between 10% and 20%).

CRITIQUE

Owing in part to the relatively high level of energy-intensive industry in Finland, the country's overall energy intensity is higher than that of its neighbours. It is thus very positive both to see energy intensity continue to decline in Finland and to see the government place such a high priority on improving energy efficiency. The country also relies heavily on combined heat and power (CHP), which helps bolster its overall energy efficiency, and does so largely without expensive and distortionary subsidies. Finally, the government is actively engaged in implementing the various EU directives and other measures. As a small country, Finland has much to gain by linking up its efficiency policies with sound policies in place in Europe and neighbouring countries, harmonising its policies as opposed to differentiating them.

Despite these positive signs, it is not clear that sufficient attention – in the form of government policies and resources – is being paid to the issue of energy efficiency. Furthermore, the policy aims do not appear to be particularly ambitious. We encourage the government to step up its energy efficiency efforts, making them a priority. While the *Action Plan for Energy Efficiency* is in place, it was last updated in 2002. It should be updated and fully integrated with the *National Energy and Climate Strategy*. The updated action plan should be based on long-term policy analysis that makes cost-effectiveness a key criterion. Such an action plan exists in the transport sector, which is a good starting point, and it should be expanded and strengthened, as well as linked with the comprehensive action plan. We also urge the government to make its policies consistent with the 16 energy efficiency policy recommendations the IEA presented to the Group of Eight (G8). These policy measures were endorsed by both G8 leaders and the IEA in 2007 (see Box 2). The good co-ordination across government ministries and other actors should help make development and implementation of such an action plan a relatively easier feat to accomplish.

Box 2

G8 Energy Efficiency Recommendations

At the Group of Eight* (G8) Summit in 2005 in Gleneagles, Scotland, the G8 countries asked the IEA to assist in developing and implementing energy efficiency policies. Responding to this request, the IEA prepared 16 recommendations for IEA countries to pursue, covering appliances, lighting, buildings, transport, industry and cross-sectoral policies, summarised below. The recommendations were subsequently endorsed by all IEA member countries in 2007 who agreed to take them forward, and we urge Finland to work to implement them.

Appliances

- Limit stand-by power use to 1 watt across all electronic appliances.
- Establish minimum energy efficiency requirements for television set-top boxes and digital television adapters.
- Establish and enforce mandatory energy performance requirements and, where appropriate, energy labelling across the full range of mass-produced equipment.
- Require individual and networked devices to enter low-power modes automatically.

Lighting

- Adopt best practice in lighting energy efficiency.
- Phase out the most inefficient incandescent bulbs as soon as commercially and economically viable.

Buildings

- Make voluntary energy efficiency requirements for new buildings mandatory and strengthen mandatory requirements such that they aim to minimise total costs over a 30-year lifetime.
- Promote very low-energy buildings to ensure they are commonly available on the market by 2020.
- Monitor, collect and analyse information on energy efficiency in existing buildings and on barriers to energy efficiency.

Transport

- Implement a fuel-efficient tyre programme.
- Introduce mandatory fuel efficiency standards for cars and vans.
- Adopt international test procedures for measuring tyre rolling resistance and require the fitting of a tyre-pressure monitoring system.

Industry

- Improve the coverage, reliability and timeliness of industries' energy-use data.

Cross-sectoral

- Provide adequate resources for countries' energy efficiency policy agencies and publish energy efficiency action plans.
- Encourage investment in energy efficiency by adopting a common energy savings verification protocol, reviewing fiscal incentive programmes and collaborating with the private financial sector.
- Report progress in the implementation of the proposed energy efficiency actions to the IEA.

* The Group of Eight is an international forum for the governments of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States.

Currently, as in many IEA countries, most efforts are focused on voluntary agreements with industry. It is impressive that Finland's voluntary agreements cover such a large share of total energy consumption. Furthermore, the government has made *ex post* analysis of the voluntary agreements a major feature of their ongoing implementation. Overall, the results of those agreements have also been very positive. Although initial estimates suggested that they would save a total of 5.5 TWh at the end of 2005, the actual estimated result is 7.1 TWh – a 30% overachievement.

There are many benefits to voluntary agreements, most notably that they can be tailored to the needs of particular industries or sectors and do not use a one-size-fits-all approach that can result in costly inefficiencies. One of their weaknesses, however, is that extensive *ex ante* and *ex post* monitoring and evaluation are necessary to understand the full impacts of the agreements – namely, that the results stem from the voluntary agreements and would not have taken place in their absence. In this light, the regular and transparent evaluation, reporting and verification process conducted by Motiva Oy is very commendable. The government should continue to ensure that sufficient monitoring and enforcement are in place to realise the full efficiency gains of these agreements. Along these same lines, the goals set within the context of voluntary agreements are the result of collaboration and negotiation between the government and particular sectors and industries. The goals that are likely to be set are ones that the industry or sector is certain it can meet – and not necessarily stretch goals or the most cost-effective goals. We encourage the government to ensure that its voluntary agreements are sufficiently stringent and provide measurable efficiency gains, taking into account international

competitiveness concerns. They should also be designed such that there are cost-effective incentives to go beyond the stated targets of the agreement and further improve efficiency. Finally, while voluntary agreements can provide significant efficiency gains, the government should consider complementing them with other policies and measures, particularly in the industrial sector. A more holistic approach that equalises the marginal costs of energy efficiency improvements across sectors through market-based mechanisms or incentives should be further explored as a means to complement the EU-ETS. This is particularly important as the EU-ETS only impacts the industrial and energy sectors directly.

As in all Nordic countries, Finland's building efficiency codes are relatively stringent compared to those of other European and North American IEA countries – which is particularly important given that Finland has one of the highest space heating needs in all of Europe. The country sets maximum building component standards, but also gives builders the option to use a building envelope standard instead that provides a 20% cushion. There are benefits to this approach – it gives flexibility to builders who would prefer the more stringent but less regulatory burdensome component standards. However, the gain in flexibility is offset by a loss in overall efficiency. Given the country's high heating load, it should consider making the flexibility component part of driving further efficiency improvements, rather than exempting builders from them. For example, the government should consider the model in place in Sweden, where component standards are complemented by a comprehensive building performance standard. In this case, both sets of standards must be achieved simultaneously and the building performance standard is more stringent than the sum of the component standards. This gives builders flexibility with regards to where they will over-comply with the standards, rather than where they will under-comply. The stringent energy performance standards only regulate total energy use as a function of floor area, leaving builders with flexibility in how to meet the more comprehensive performance standard.

In addition to considering this more stringent regulatory approach, Finland should consider tightening its component standards, as they are higher than those in other Nordic countries – especially when builders take advantage of the 20% cushion in the building envelope option. Possibilities likely exist to tighten the values further on the basis of lifetime cost-benefit analysis. Furthermore, while building envelope standards are in use covering ventilation and air-tightness, energy performance standards are not used. Setting energy performance values that include efficiency for heating and cooling systems could further drive energy efficiency improvements, as is the case in other Nordic countries.

In the longer term, Finland should consider moving towards implementing policies that drive development of efficient houses, such as passive houses (in which a comfortable indoor climate is achieved without a traditional heating or cooling system), and adopting policies that ensure that the necessary technologies are available on the market. Building a passive house generally requires that the building be highly insulated, have tight-fitting comfort windows, be very air-tight, have efficient mechanical ventilation and use innovative heating technology, among other building technologies. Estimates show that the energy demands of passive houses are 50% to 70% less than those of traditional houses. Costs for building passive houses are only slightly higher than those for traditional buildings because the additional costs are outweighed by the savings from not installing a traditional heating system. In general, the payback time is about 20 to 25 years. Finland should aim its policies towards the long-term installation of a passive-house stock – a goal that, if met, would have very large benefits for Finland's energy consumption, security and need for imports.

Energy consumption in the transport sector is rising modestly, with an annual increase of just 0.6%. A new long-term strategy was adopted in April 2007, *Traffic 2030*, which identifies energy efficiency and the reduction of CO_2 emissions as prime targets. We are pleased to see this new strategy, as it can help drive greater gains in the sector. Until now, measures taken include sustainable transport system planning in conjunction with urban land use planning, voluntary energy saving agreements with public transport carriers and drivers' associations and ecodriving campaigns, among others. Despite these efforts, transport consumption is relatively high. Owing to the high share of gasoline-fuelled vehicles, among other factors, the average CO_2 emissions of the Finnish fleet are 180 g per km, above the EU average of 165 g per km and 50% above the proposed EU goal of 120 g per km for 2012.

In this light, the recent legislation to implement vehicle taxation based on carbon dioxide consumption is a very positive step and will likely become a model for Europe. Not only will it create additional incentives for customers to invest in more fuel-efficient vehicles, but it will also help improve regional air quality as it should lower emissions of nitrous oxides and particulates in the longer term. In addition to these welcome tax revisions, other options to consider are road pricing that increases the price of private passenger vehicle transport, congestion charges that discourage private vehicles during peak travel times, higher parking charges and other fiscal incentives. Improvements in public transportation will also help improve transport efficiency. The government already focuses on enhanced transport planning, and we welcome the additional funding that the recent transport legislation will provide to public transportation, particularly in major urban areas.

RECOMMENDATIONS

The government of Finland should:

- *Step up efforts to increase energy efficiency, in part by updating the* Action Plan for Energy Efficiency, *creating an integrated and long-term plan across all sectors.*
- *Work towards policies that are consistent with the 16 IEA energy efficiency policy recommendations presented to the Group of Eight (G8) Summit.*
- *Continue to evaluate the effectiveness of voluntary agreements and ensure that cost-effective stretch targets are set and that sufficient cost-effective incentives, along with monitoring and enforcement, are in place to achieve the efficiency gains.*
- *Continue to strengthen energy efficiency policies in the building sector and:*
  - *Consider setting comprehensive building envelope or building performance standards that exceed the sum of building component standards.*
  - *Consider tightening building component standards in a cost-effective manner.*
  - *Work to promote highly efficient houses, such as passive houses.*
- *Build on momentum to improve transport efficiency through differentiated vehicle taxation and greater support for public transportation by considering additional measures such as road pricing, congestion charges and other fiscal incentives.*

Of IEA countries, Finland has the fourth-largest share of renewables in its primary energy supply, nearly a quarter, driven mostly by its extensive use of biomass and hydropower. It has a negligible amount of new renewable energy technologies such as wind and solar, though estimates suggest that there may be great potential for additional technologies. Some subsidies and tax reductions are already in place for particular renewables and a more comprehensive promotion scheme for renewable electricity production is under consideration.

SUPPLY-DEMAND BALANCE

PRIMARY ENERGY SUPPLY

Renewables make up over 20% of total primary energy supply (TPES), a share that has held relatively steady since the mid-1970s, though it has been increasing somewhat in recent years. As shown in Table 9, almost 85% of renewables supply

Table 9

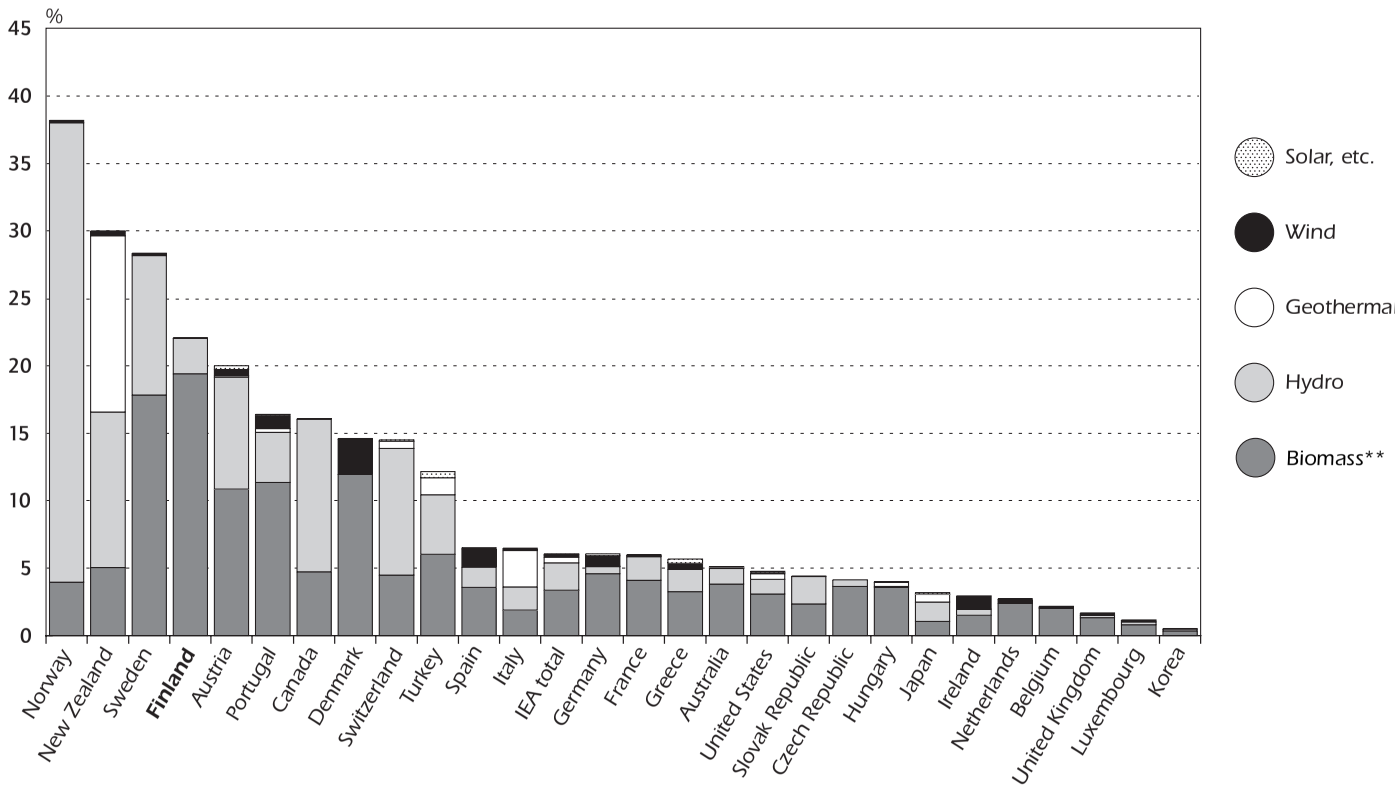
Renewable Primary Energy Supply, 1970 to 2005

Unit: ktoe	*Biomass**	*Hydro*	*Solar, wind, etc.*	*Total*	*Share of renewables in TPES*
1970	4 178	796	0	4 974	28%
1980	3 463	879	0	4 342	17%
1990	4 555	934	0	5 489	19%
2000	6 465	1 261	7	7 733	23%
2001	6 250	1 136	7	7 393	22%
2002	6 726	927	6	7 659	22%
2003	6 895	825	9	7 729	21%
2004	7 242	1 296	11	8 549	23%
2005	6 743	1 185	15	7 944	23%
Share of renewables TPES in 2005	84.9%	14.9%	0.19%		
Share of total TPES in 2005	19.3%	3.4%	0.04%	22.7%	
Change (1990-2005)	48%	27%	3920%	45%	
Annual change (2000-2005)	0.8%	–1.2%	16.2%	0.5%	

* excludes industrial and non-renewable municipal waste.
Source: *Renewables Information*, IEA/OECD Paris, 2007.

Figure 7

Renewable Energy as a Share of TPES in IEA Countries, 2006*



* estimates. ** excludes industrial and non-renewable municipal waste.

Source: *Renewables Information*, IEA/OECD Paris, 2007.

comes from biomass, and total biomass supply has increased by almost 50% since 1990. The remainder of renewables supply comes almost exclusively from hydro. Less than 0.2% of renewables comes from new renewables such as solar and wind.

As shown in Figure 7, Finland has the fourth-highest share of renewables in its TPES, following only Norway, New Zealand and Sweden, countries that rely heavily on hydro. At over 19%, Finland has the highest share of biomass in TPES of any IEA country.

ELECTRICITY

As shown in Table 10, in 2005 one-third of Finland's electricity was generated from renewables, mostly hydro (20%) and biomass (13%). Biomass has been used in Finland to generate electricity for a long time, even before 1970, especially in the pulp and paper industry (though IEA data only break out biomass in electricity generation since 1992). It now makes up 41% of total electricity generated from renewables.

Table 10

Electricity Generation from Renewables, 1970 to 2005

Unit: ktoe	*Hydro*	*Biomass**	*Solar, wind, etc.*	*Total*	*Share of renewables in total electricity generation*
1970	9 258	*n.a.*	0	*n.a.*	*n.a.*
1980	10 216	*n.a.*	0	*n.a.*	*n.a.*
1990	10 859	*n.a.*	0	*n.a.*	*n.a.*
2000	14 660	8 533	80	23 273	33%
2001	13 205	8 331	72	21 608	29%
2002	10 776	9 755	66	20 597	27%
2003	9 591	9 584	95	19 270	23%
2004	15 070	10 409	122	25 601	30%
2005	13 784	9 491	173	23 448	33%
Share of renewables TPES in 2005	58.8%	40.5%	0.74%		
Share of total TPES in 2005	19.5%	13.5%	0.25%	33.2%	
Change (2000-2005)	–6%	11%	116%	1%	
Annual change (2000-2005)	–1.2%	2.2%	16.7%	0.1%	

n.a. = not available. * excludes industrial and non-renewable municipal waste.
Source: *Renewables Information*, IEA/OECD Paris, 2007.

TRANSPORT FUELS

There was no consumption of biofuels (such as biodiesel or bioethanol) in the transport sector in 2005, but consumption totalled 10.1 thousand barrels in 2006.

Finland's ethyl tertiary butyl ether (ETBE) production capacity is currently estimated at 2.18 thousand barrels per day (kb/d). The ethanol contained in the ETBE is imported. While Neste Oil is set to be dominant in the biofuels market in Finland, there is 0.75 kb/d of new bioethanol capacity coming on line from the privately owned fuel station chain St1, which early in 2006 announced plans to build six to ten biofuels production plants in Finland over the next two years, using food and grocery industry waste as raw material. In addition, Neste Oil has started producing biodiesel in the plant it has built in Porvoo. The plant's capacity is 3.7 kb/d. A second, similar plant is expected to be completed at the end of 2008. This would bring the biodiesel capacity to 7.4 kb/d.

POLICIES AND MEASURES

OBJECTIVES

Finland's 2005 *National Energy and Climate Strategy* has a number of objectives as regards renewables:

- Consumption of renewable energy should grow by at least one-fourth by 2015 and by at least 40% by 2025 such that renewable energy accounts for almost one-third of primary energy by 2025.
- The use of forestry chips, energy crop-derived biomass, biogas and small-scale wood facilities should increase by approximately 65% by 2015 and by about 80% by 2025 as compared to 2003.
- In 2010, renewable electricity should account for 31.5% of total Finnish power consumption.
- Biofuels should account for 5.75% of road transport fuels in 2010.

POLICIES AND MEASURES

Finland generally takes a cost-effective approach to renewables promotion, and most promotion policies are typically targeted and limited in scale. Current policies and measures are listed below, along with current average annual spending. Total annual support for renewables is about EUR 85 million.

- Implementation of EU directives, including on renewable electricity, renewables for transport, renewables in CHP and others (EUR 15 million).
- Research and development on new renewable energy technologies (EUR 15 million).
- Subsidies for investments in energy production in combined heat and power (CHP) plants, wind power plants and in the heating sector. Investments in new technology are prioritised. Subsidies go primarily to support biomass (EUR 25 million).
- Legislation on biofuels for transport, which gives the obligation to oil companies to have minimum shares of biofuels in their sales of transport fuels. These minimum shares are 2% in 2008, 4% in 2009 and 5.75% in 2010, in line with the EU directive on biofuels.
- Development programme for second-generation biofuels to finance pilot and demonstration plants using, for example, wood biomass as a raw material (EUR 4-5 million).
- Subsidies for renewable energy heating systems in residential buildings to encourage investments to change from high shares of existing electric heating and oil heating to district heating, wood pellets, heat pumps or other forms of renewable energy (EUR 4-5 million). (About one-third of the heating demand of detached houses comes from electric heating as a principal heating source or as an additional source.)
- Support for energy wood harvesting and chipping to encourage forest owners to supply wood residues to energy markets (EUR 6 million).
- Support for energy investment in the agricultural sector, mainly for biogas plants and wood-based heating plants (EUR 5 million).
- Support for renewable electricity production funded from the electricity tax on consumers (EUR 10 million):
  - EUR 0.69 per kWh tax support for electricity produced from forest chips and wind.
  - EUR 0.25 per kWh tax support for electricity produced from recycled fuels.
  - EUR 0.42 per kWh tax support for electricity produced from other renewable sources.
- Information activities to increase motivation, primarily of small-scale consumers such as single-family house-owners, to select options such as wood pellets or heat pumps for their heating source (EUR 1-2 million).

The government is also considering a feed-in tariff or green certificates to further promote renewables. Unlike most IEA countries, particularly in Europe, Finland does not currently have a comprehensive feed-in tariff or certification scheme in place.

POTENTIAL FOR ADDITIONAL RENEWABLES

Most renewables capacity in Finland is in the form of hydro and biomass. New analysis of other renewable energy technologies has recently given more accurate figures for their potential in Finland:

- *Hydro.* According to a report prepared by Finnish Energy Industries for MEE, there is a total additional potential of 9.7 TWh annually. However, most of that potential is located in places that are either protected from development, uneconomic to develop, or both. The total economic potential in unprotected areas is about 1 TWh annually.
- *Biomass.* Additional techno-economic potential has been estimated up to 30 TWh annually of fuel energy in 2020 on the basis of analysis by Pöyry Energy, the Ministry of Agriculture and Forestry and the Ministry of Employment and the Economy. The additional biomass would be used mainly as wood chips in CHP plants, equivalent to 15 TWh annually. Possibilities to increase the use of biomass are closely connected to the forestry and forest industry sector, meaning that changes in forest industry production have large influences on biomass potential.
- *Wind power.* The theoretical potential in Finland is large, though the wind resource is not of as high a quality as in Denmark and Norway, and freezing seas make offshore wind projects challenging. Furthermore, costs have increased owing to high global demand. Nevertheless, according to analysis prepared by Pöyry Energy for MEE, the realisable potential for wind in Finland ranges up to 6 TWh annually through 2020.

CRITIQUE

Ranking fourth among IEA countries in terms of its renewables supply share, Finland already places a very high priority on its renewables industry, particularly its biomass sector. Renewables make up almost a quarter of primary energy supply and a third of electricity generation. Biomass alone makes up nearly 20% of the country's energy supply and 13% of electricity – the highest share in the IEA. As IEA countries are working to enhance their reliance on renewable resources, both for environmental and security of supply reasons, Finland is already working from an enviable starting point.

Biomass is a priority research and development area for the government. The country has favourable biomass resources and to make use of them, measures to promote them are part of the 2005 *National Energy and Climate Strategy*. Surveys on the potential for increased production of biomass from the forest industry and energy crops from the agricultural sector have been made. Even if the potential for domestic biomass resources is large, it is not unlimited. More importantly, there is strong competition from all different uses of biomass. The agriculture and forestry sectors, the pulp and paper industry, the

transport fuels industry and energy sectors are all looking to the future of biomass in Finland and Europe with their own respective self-interest – a future that cannot maximise the use of biomass in all sectors simultaneously. There is therefore a need to find synergies between the various parties to establish healthy markets. A balanced, realistic view should be taken so that Finland's existing and future biomass resources are developed in the most sustainable and cost-effective manner possible.

One of the most effective ways of reducing carbon dioxide emissions is to use biomass for combined heat and power production, which Finland already does to a large extent by drawing largely on the by-products of its pulp and paper industry. This provides excellent energy efficiency, particularly if the latent heat of condensation in the flue gases is recovered. The climate benefit of increasing the use of biomass for district heating and CHP production is considerable. Turning to biofuels for transport, the new 5.75% EU biofuels target will be difficult for Finland to meet, and will not provide the same climate and efficiency benefits of the biomass that Finland is already using in the electricity sector. With present-day methods, a relatively large quantity of energy is required for the production of liquid biodiesel and bioethanol, so that such processes are not likely to be energy-efficient in the near future.

New analysis of the potential penetration of new renewables in Finland (other than traditional biomass) has given more accurate figures of the possibilities. The government should continue to investigate these options so that they may be developed and deployed in a cost-effective manner, taking into account the geographic and other realities of Finland. When developing a support scheme for these new renewables, care should be taken to harmonise the system as much as possible with neighbouring countries, particularly given Finland's participation in Nord Pool. The government might also avoid technology-specific support. Ensuring a market-based means of promoting new renewables will allow the promotion scheme to harmonise cost-effectively with the Nordic electricity market, as well as to incorporate the carbon price signal established by the European Union emissions trading scheme (EU-ETS). If a new renewables promotion scheme is implemented, it should be integrated with the policies and measures already in place. While these measures are generally targeted and small, care should be taken to ensure that new measures are not simply layered on top of existing measures.

As discussed here and in Chapter 7, Finland has a relatively high share of electric space heating – about one-third of the heating load of detached houses in Finland is produced by direct electric heating. This heating system is costly and contributes to higher peak electricity loads. However, converting direct electric heating to alternative heating systems, such as wet central heating systems, is uneconomic, requiring subsidies. If a conversion is made, a renewable energy source such as a wood-pellet burner, or a ground-coupled heat pump, may be economically installed at the same time. Heat pump

systems are not as popular in Finland as in Sweden and Norway, even though the pay-off times for house-owners are reasonable even without subsidies, especially with expected higher electricity prices. The government should do more to encourage such conversions, such as using public information campaigns.

RECOMMENDATIONS

The government of Finland should:

- *Leverage R&D efforts in renewables by enhancing deployment and promotion policies.*
- *Investigate how new renewables in Finland can be developed cost-effectively, in order to make full usage of the country's natural resources.*
- *Develop a realistic and balanced vision for the long-term role of biomass in Finland, in light of competing policy goals and uses for biomass resources.*
- *Facilitate cost-effective conversion of the relatively large share of houses with direct electric heating to more flexible heating systems, such as wet central heating systems that use renewable energy.*

With almost no domestic resources of its own, imports form the basis of most of Finland's fossil fuel consumption. The exception is peat, a domestic resource that provides about 5% of primary energy supply. Most imports come from Russia; Finland's gas requirement is met entirely from imports from Russia. In general, high priority is placed on security of supply, and alternative import options are being considered. To encourage sustained production of peat in the face of negative incentives from the European Union's emissions trading scheme (EU-ETS) for greenhouse gases, a premium tariff scheme has been put in place to subsidise peat.

COAL

SUPPLY AND CONSUMPTION

In 2005, coal (excluding peat) accounted for 3.3 Mtoe, or 9.4% of Finland's TPES. All coal is imported as there is no local production. Finland imported 3.4 Mtoe in 2005 and 4.6 Mtoe in 2006, consistent with the annual average level of imports since 1980 of just below 4.0 Mtoe. In 2005, nearly all steam coal imports of 3.3 Mt were provided by Russia (82%) and Poland (17%). Imports of coking coal, totalling 1.4 Mt, came mainly from Canada, Australia and the United States.

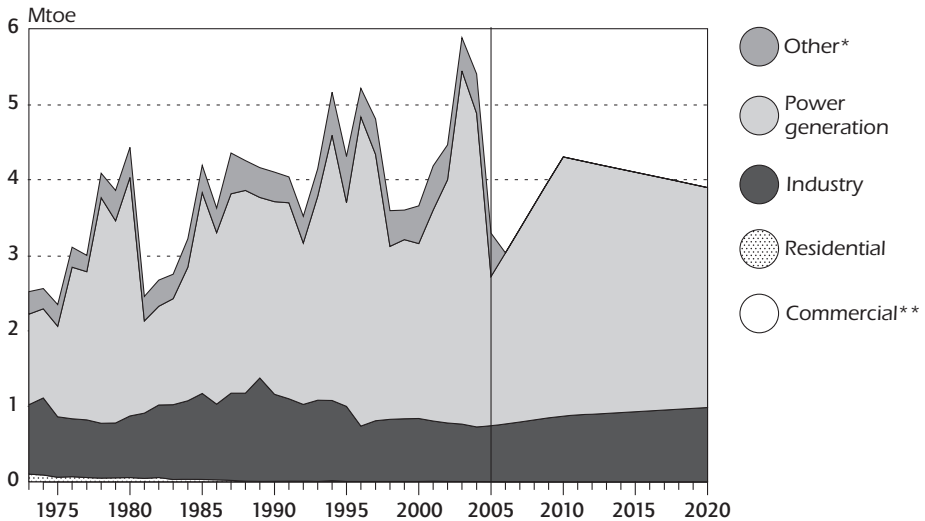
About three-quarters of all coal consumption in Finland is in the electricity and heat sector, with the remainder used in the iron and steel industry, as shown in Figure 8. Driven by hydrological conditions in Nordic countries, consumption of coal varies considerably from year to year. In 2005, coal use was significantly reduced owing to the increase in imported electricity as it was a very wet year. In 2006, however, the price of electricity in the Nordic wholesale market was very high, reflecting dry conditions, making the use of imported steam coal as fuel for conventional coal-fired power plants economically viable. Finland used coal-fired power to compensate for the diminished production of hydropower in the Nordic countries.

In Finland, between 2000 and 2006, about 60% of all steam coal was used in conventional coal-fired power plants, nearly 40% was employed for district heating in combined heat and power (CHP) plants and 3% was used in industrial CHP plants as backup fuel.

The use of coal in the CHP plants for district heating is relatively stable, about 2 Mt per year. The key factors affecting variation are the weather and the price of natural gas, since most coal-fired CHP plants can also be fired with natural gas. There are two coal-only district heating projects in Finland. The first is Helsingin Energia's Salmisaari CHP plant, which was completed in 1984. The other is the district heating project that covers the entire west coast, which does not have any access to natural gas and thus relies exclusively on coal. In this project, the biggest plants are Fortum's Naantali, completed between 1960 and 1972, and PVO's Vaskiluoto, completed in 1982. The 560-MW Meri-Pori supercritical coal-fired power plant went on line in 1993 and is a good example of efficient power generation from coal.

Figure 8

Coal Consumption by Sector, 1973 to 2020



* includes transformation, own use in the energy sector and non-energy use. ** negligible.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

Government estimates indicate that, as from 2010, coal consumption will begin to decline, driven by the European Union emissions trading scheme (EU-ETS).

PEAT

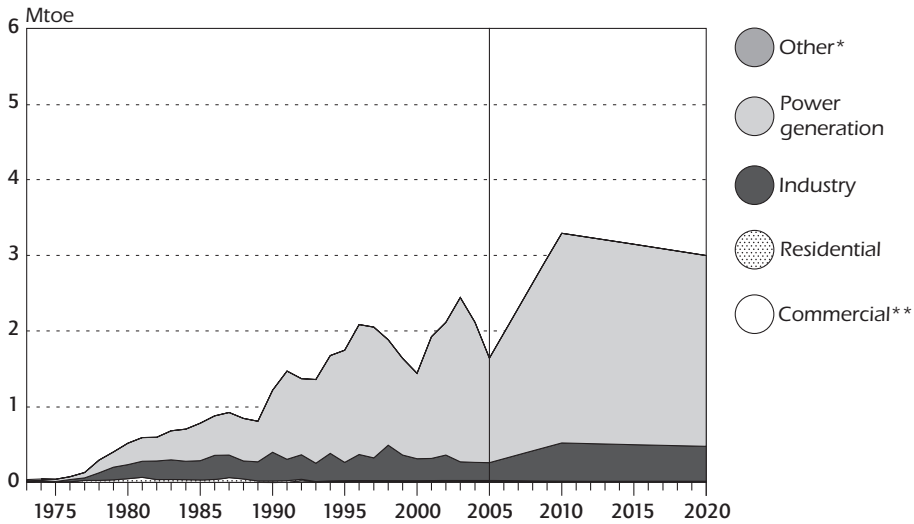
SUPPLY AND CONSUMPTION

In contrast to most IEA countries, peat is a significant power source in Finland.[7] In 2005, the total supply of peat was 1.6 Mtoe, representing 4.7% of Finland's TPES. Turning to total production, peat production has increased 100-fold since 1970 – from 0.02 Mtoe in 1970 to 2.13 Mtoe in 2005. This rapid rise after the two oil crises in the 1970s is the result of government support and policy to maintain the domestic resource in the fuel mix. Finland has considerable peat resources; approximately one-third of its land area consists of peat lands.

As shown in Figure 9, peat consumption has grown rapidly through the mid-1990s, then fluctuated considerably. This is in contrast to coal consumption, which has been very variable, but has stayed primarily at the same general level since the 1980s. Government estimates indicate that peat consumption will roughly double between 2005 and 2010, to reach 3.3 Mtoe.

Figure 9

Peat Consumption by Sector, 1973 to 2020



* includes transformation, own use in the energy sector and non-energy use. ** negligible.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

7. Peat has low energy and high moisture content, making it uneconomic to transport great distances. It is, therefore, generally used locally for electricity and heat production, and is neither imported nor exported for fuel use. While biomass is considered a renewable resource because it regenerates on a time-scale similar to its consumption, the rate of depletion of peat far outpaces its natural replenishment at mine sites. Thus, peat is generally not considered a renewable fuel. Finland classifies peat as a "slowly renewing biomass fuel".

There are two large peat producers in Finland: Vapo Oy, which is half-owned by the State, and Turveruukki Oy, which is jointly owned by a group of municipalities. There are also approximately 200 to 250 small-scale producers, which share roughly 10% of total production.

Peat is used principally for CHP production, making up 22% of the fuel used by all CHP plants (including industrial CHP). It is often used inland, competing with coal and biomass, as natural gas does not currently penetrate to inland Finland. In district heating-only plants, this share is 19%, while it is 8% for conventional electricity-only power plants. Peat is typically co-fired with biomass, leading to a higher efficiency ratio. There are about 55 large peat-fired CHP power plants, those with an output of 20-550 MW_{th}. Total installed capacity is approximately 7 200 MW_{th}. Peat-fired power plants are municipal or industrial plants, though some serve both sectors. Industrial power plants exist mainly in the forest sector, where peat is used to improve the heat value of biomass by-products from the sector.

Large investments have been made in recent years in peat-fired plants and especially for the integrated use of peat and wood, as co-firing of peat and wood reduces the sulphur dioxide emissions of peat combustion.

PEAT PROMOTION POLICY

Stemming from effects of the EU-ETS, peat use is estimated to decrease in Finland owing to its relatively high CO_2 emissions. To counteract the effect of the EU-ETS, the government implemented a peat promotion scheme at the beginning of May 2007 in the form of a premium tariff[8] for peat used in conventional power plants. The tariff for peat is set to sunset at the end of 2010. Under the premium tariff scheme, Fingrid, the country's transmission system operator for electricity, pays qualified facilities an additional premium for any electricity sold into the market. This premium paid to qualified peat-fired generators does not directly affect the market price within Nord Pool, the Nordic electricity market of which Finland is a part.

The additional payment, which is calculated *ex post* on a monthly basis, is determined according to a complex formula that takes into account a number of variables, including coal and peat prices and the price of EU-ETS emission credits. Because the premium formula includes the price of emission credits – the premium paid increases when CO_2 permit prices rise – it effectively counteracts the pressure the EU-ETS puts on the market to move away from more CO_2-intensive fuels.

8. This premium tariff differs from a traditional feed-in tariff in that it is a payment provided in addition to the electricity market price, thus the full payment to generators varies with the market price. Under a traditional feed-in tariff scheme, the qualified generator receives a fixed payment, completely independent of the market price for electricity.

The power plants within the premium tariff arrangement for peat are Kanteleen Voima Oy (Haapavesi power plant), Alholmens Kraft (Pietarsaari power plant), Vaskiluodon Voima (Seinäjoki power plant) and Oulun Energia (Toppila power plant). Depending on power plant type, there is a cap on the total number of hours for which a generator can receive the premium.

In addition to the premium paid to peat-fired electricity generation, the taxes on peat in heat production were suspended in July 2005.

OIL

SUPPLY-DEMAND BALANCE

As detailed in Table 11, oil accounted for 10.7 Mtoe of Finland's TPES in 2005, a 4.7% decrease from the previous year but an 11.2% increase from 2000.

Table 11

Oil Supply-Demand Balance, 1970 to 2020

Unit: Mtoe	*1970*	*1980*	*1990*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*2010*	*2020*
Supply											
Indigenous production	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Imports	13.0	16.5	12.5	16.0	15.4	16.0	17.3	17.1	16.4	9.4	9.0
Exports	–0.4	–2.1	–1.7	–5.2	–5.0	–5.5	–5.7	–5.8	–5.2	0.0	0.0
Other	–1.8	–0.9	–0.5	–1.2	–1.0	–0.1	–0.9	–0.2	–0.6	0.0	0.0
Total supply (TPES)	*10.7*	*13.4*	*10.3*	*9.6*	*9.4*	*10.4*	*10.7*	*11.2*	*10.7*	*9.4*	*9.0*
Demand											
Transport sector	2.1	3.0	4.3	4.4	4.5	4.6	4.7	4.8	4.9	4.4	4.3
Industrial sector	3.4	3.8	2.6	1.9	1.7	2.2	2.5	2.4	2.4	2.8	2.8
Residential sector	3.0	3.0	2.1	0.7	0.8	0.8	0.7	0.7	0.6	0.7	0.6
Other final consumption*	0.5	0.5	0.7	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1
Subtotal (TFC)	*9.0*	*10.3*	*9.7*	*8.0*	*8.0*	*8.6*	*8.9*	*8.9*	*8.9*	*9.0*	*8.7*
Other (including electricity and losses)	1.7	2.5	1.3	1.3	1.5	1.5	1.6	1.6	1.4	0.3	0.3
Subtotal (total demand)	*10.7*	*12.8*	*11.0*	*9.3*	*9.6*	*10.0*	*10.5*	*10.5*	*10.2*	*9.4*	*9.0*

* includes commercial/public services, agriculture/forestry, fishing and non-specified.
Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

In 2005 it accounted for 8.9 Mtoe of TFC, with more than half (55%) used in the transport sector. Over a quarter of oil consumption comes from industrial demand. The residential sector used 7% of TFC in 2005, with the remainder used in commercial and other sectors. When compared to its neighbours, Finland has a relatively higher share of oil used for space heating versus other fuels. Its share in 2004 was 22%, lower than the IEA average of 23%, but above the value for Norway, Sweden and Denmark of 12%.

Finland has no domestic oil production. Of its imports, 81% came from Russia in 2005, 10% from Denmark, with the remainder from the United Kingdom, Kazakhstan and Norway. Russia's contribution to Finland's crude oil imports has been rising over the past few years.

REFINERY OUTPUT AND PRODUCT EXPORTS

Neste Oil, the largest oil company in Finland, owns the two oil refineries in Finland (Porvoo and Naantali). The total refining capacity of the refineries is about 14 Mt per year (250 000 b/d). In 2005, capacity utilisation at Finland's refineries was lower than usual because of the five-week shut-down for maintenance work at the Neste Oil Porvoo refinery.

Neste Oil's largest-ever investment (EUR 600 million) in a new diesel production line at the Porvoo refinery went on line in June 2007. The new production line uses residual fuel oil to produce sulphur-free, clean motor fuels, particularly diesel fuel. The production of diesel oil will increase by 1 Mt per year. However, the overall capacity of the refinery will remain the same. The fuel will meet the latest environmental requirements in Europe and North America. As Europe is short on cleaner diesel fuels, the new diesel fuel products will most likely be destined for western European markets. Traditionally, some of Neste's clean gasoline products have been exported as far as North America.

INDUSTRY STRUCTURE

Wholesale market

Finland's oil market is fully liberalised. Import restrictions were lifted in July 1991. The largest oil company in the Finnish market is Neste Oil, a majority state-owned company, whose activities cover the refining and marketing of oil, shipping and engineering services. Neste Oil's shares are quoted on the Helsinki Stock Exchange.

Retail and distribution

In addition to Neste Oil, other companies active in the distribution of oil products in the Finnish market include ConocoPhillips Finland (JET), Esso, Shell, Teboil, ST1, the S Group's ABC chain and NEOT (as a fuel procurement company for ABC and ST1). In the Finnish gasoline market in 2005, Neste's share was 27%, Teboil's was 15%, ABC's was 15%, Shell's was 14% and Esso's was 11%. In the diesel oil market in 2005, Neste's share was 41% followed by Teboil's 27% and Shell's 13%.

In the sales of gasoline and diesel oil, the total number of manned and automatic unmanned service stations totalled 2 000. The range of different service stations has widened over the years, but the total number has remained fairly constant; as in 1975, there were 1 970 stations. The number of unmanned stations has increased; in 2000 there were 548 unmanned stations, and in 2005, 898.

TRANSPORT FUELS

Finland's relative use of gasoline and diesel has shifted slightly in recent years. Gasoline had a 56% share of road transport fuels in 1990, which fell to 48% in 2005. Diesel consumption in road transport now outpaces gasoline consumption. Of the 20 European countries in the IEA, the share of diesel in road transport consumption is the fifth-lowest in Finland, roughly equivalent to the share in neighbouring Scandinavian countries. Absolute consumption of gasoline has been declining at an average annual rate of 0.4% since 1990, while absolute consumption of diesel has been growing at an average annual rate of 1.8% since 1990.

EMERGENCY RESPONSE MEASURES

With 127 days of oil stocks on average in the first three quarters of 2007, Finland has been in full compliance with the IEA oil stockpiling requirement to hold 90 days of net oil imports. Finland meets its stock obligation by holding stocks in a state agency, the National Emergency Supply Agency (NESA), and by placing an obligation on industry. The government imposes a minimum obligation on oil importers to hold 60 days of cover based on the previous calendar year's consumption. Of the 127 days of stocks, 51 were held by NESA and 76 were held by industry for both commercial and operational purposes and to meet the minimum stockholding requirement. In addition, several industries are required to hold two months' equivalent volume of their stock sales.

SUPPLY-DEMAND BALANCE

Currently, natural gas has a 10% share of TPES, a share that the government forecasts will rise to 13% by 2020. With no domestic resources and only one import link, Finland has been importing all of its natural gas requirements from one source, Russia, since 1974.

As described in Table 12, total consumption of gas was 4.4 billion cubic metres (bcm) in 2005, representing an 11% decline from the peak in 2003. Peak gas demand, however, is rising, reaching 8 330 MW (about 21 million cubic metres per day) in February 2007. Currently almost 70% of natural gas consumption is for electricity generation, a share that has been more or less steady since 2000. Natural gas provides about one-sixth of Finland's power production. One-fifth of gas consumption is in the industrial sector.

Table 12

Natural Gas Consumption, 1970 to 2005

Unit: Million cubic metres	*1970*	*1980*	*1990*	*2000*	*2001*	*2002*	*2003*	*2004*	*2005*	*Change 1990-2005*	*Change 2000-2005*
Electricity	0	372	1 199	2 672	2 944	2 939	3 490	3 463	3 060	155.2%	14.5%
Share		*41%*	*45%*	*64%*	*65%*	*65%*	*70%*	*72%*	*69%*		
Industrial processes	0	487	1 156	1 134	1 194	1 156	1 076	942	949	-17.9%	-16.3%
Share		*54%*	*43%*	*27%*	*26%*	*26%*	*21%*	*19%*	*21%*		
Transport	0	0	0	18	26	26	33	28	25	*n.a.*	38.9%
Share		*0%*	*0%*	*0%*	*1%*	*1%*	*1%*	*1%*	*1%*		
Energy sector (excluding electricity)	0	0	276	299	304	320	325	318	311	12.7%	4.0%
Share		*0%*	*10%*	*7%*	*7%*	*7%*	*6%*	*7%*	*7%*		
Other	0	43	50	76	83	88	87	89	90	80.0%	18.4%
Share		*5%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*	*2%*		
Total consumption	**0**	**902**	**2 681**	**4 199**	**4 551**	**4 529**	**5 011**	**4 840**	**4 435**	**65.4%**	**5.6%**

Source: *Natural Gas Information*, IEA/OECD Paris, 2007.

There is no gas storage in Finland; gas supply security is guaranteed by strong policies to ensure that most consumption can switch to alternative fuels, usually fuel oil. Major gas plants (both CHP and conventional power plants) have a legal obligation to have storage of reserve or alternative fuels, usually fuel oil, corresponding to three months of gas use. Industrial gas users have no obligation. Supplies to customers that can only use gas are secured by a propane-air production plant. Gas importers are obliged to maintain reserve fuel storages for small gas customers using less than 15 million cubic metres of gas per year. All other users of natural gas are primarily responsible for their own contingency plans and the associated emergency fuel supply systems, emergency fuel reserves and fuel transport. The National Emergency Supply Agency also keeps fuel oil storage to secure fuel supplies to gas users.

INDUSTRY STRUCTURE

Gasum Oy is responsible for imports, transmission and wholesale trading of natural gas in Finland. The company is owned by a consortium of Fortum (31%), OAO Gazprom (25%), the State of Finland (24%) and E.ON Ruhrgas (20%). Gasum Oy is the country's only transmission system operator.

There are over 30 regional distribution companies that sell gas to residential customers and other small-scale users. The owners of these distribution companies are typically local electricity companies. Some distributors are partly owned by Gasum Oy, while Gasum Oy itself has 50 customers, including both distribution companies and direct industrial customers. The total number of gas customers in Finland is 35 525. A large number of households receive heat and power from natural gas-run CHP plants.

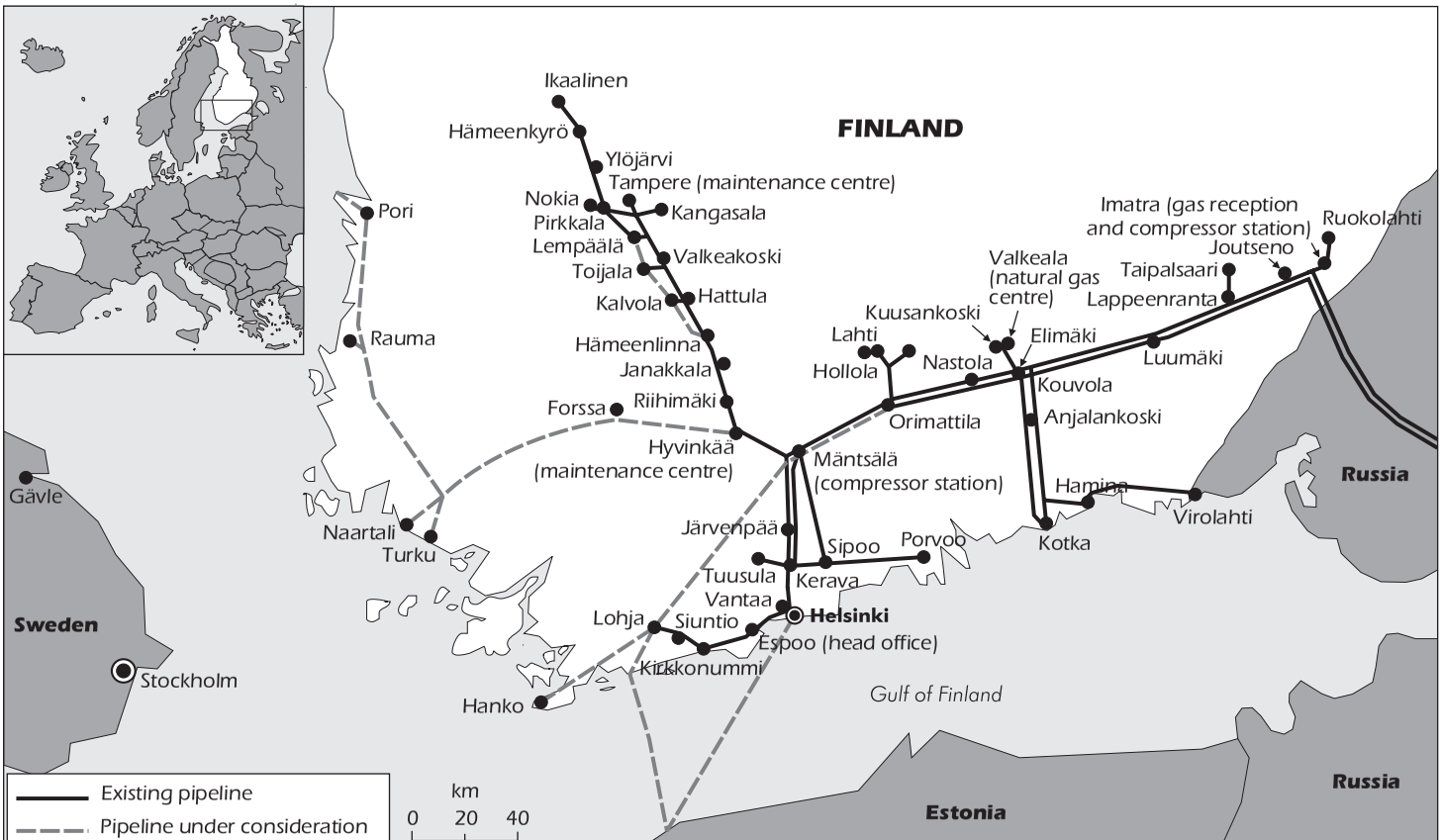
GAS NETWORK AND INFRASTRUCTURE

The transmission system, which is operated by Gasum Oy, has approximately 1 000 km of pipeline within Finland. With the distribution grid included, the total length of the gas grid is 2 600 km. As shown in Figure 7, the gas grid is currently confined to the southern region of Finland, but there are plans to extend it to the south-west regions of Hanko and Turku, with possible later extensions to the Pori region.

The maximum annual import capacity at the border with Russia is about 7 bcm. While the annual import capacity of the pipeline is more than sufficient to handle average annual imports, peak gas demand is rising faster than the average annual demand, and peak winter demand is now close to the maximum capacity at the Russian border. As Finland has no domestic gas storage, it must rely on the supplier to meet variable demand.

Figure 10

Map of the Finnish Gas Grid



Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.
Source: *Natural Gas Information*, IEA/OECD Paris, 2007.

New import infrastructure options

A potential future connection to Baltic countries via the Balticconnector is under investigation, which would also create possibilities to use storage facilities in Latvia, as Finland's geological structure makes domestic storage very expensive to build (although plans have existed for some time to build gas storage in lined rock caverns). The Balticconnector would also allow Finland to draw on European gas supplies, bringing in gas from Norway, the North Sea and elsewhere.

Companies are also exploring liquefied natural gas (LNG) options. While a large-scale LNG facility might not be appropriate for a market the size of Finland, companies are considering small-scale LNG options. For example, an independent Norwegian company is developing a project that would transport LNG in small ships (10 000 m^3 as opposed to normal tankers of 120 000 m^3) to the Scandinavian-Nordic market.

Such options could provide valuable diversity of supply and allow gas to compete in power markets through, for example, combined heat and power developments. But any new gas supplier to Finland, either by pipeline or LNG, would need to be competitive with existing gas supplies, noting that Finland benefits from lower transport costs than other western European buyers, owing to its proximity to Russia. Current LNG markets are very tight, and likely to remain so for some time, so LNG suppliers may find Finland a difficult market to penetrate, depending on price movements in all energy sources.

GAS MARKET REGULATION

The natural gas market regulator is the Energy Market Authority, which issues licences for gas network operators and ensures that gas market actors fulfil the requirements of government regulation. Market actors can appeal against the decisions of the regulatory authority to the Administrative Court or Market Court.

The basis for full market access is weak, since there is only one supplier and the network is not connected to the European gas network. Given this isolation, the European Commission has granted Finland a derogation from regulations requiring full market opening. With approval from the European Commission, Finland has opted for regulated network access. There is a postage stamp tariff for gas transmission. Gas users buying more than 5 million cubic metres (mcm) annually have access to the transmission system when trading in the secondary market. The secondary market was created in 2001 and its volume is about 1% of the entire natural gas market. The volume traded at the hub is about 0.4 bcm annually. In 2005 there were 25 active traders.

PRICES

Wholesale natural gas prices in Finland are low compared to nearly all IEA countries, making end-user prices very low for both industrial and household customers (see Figure 11).

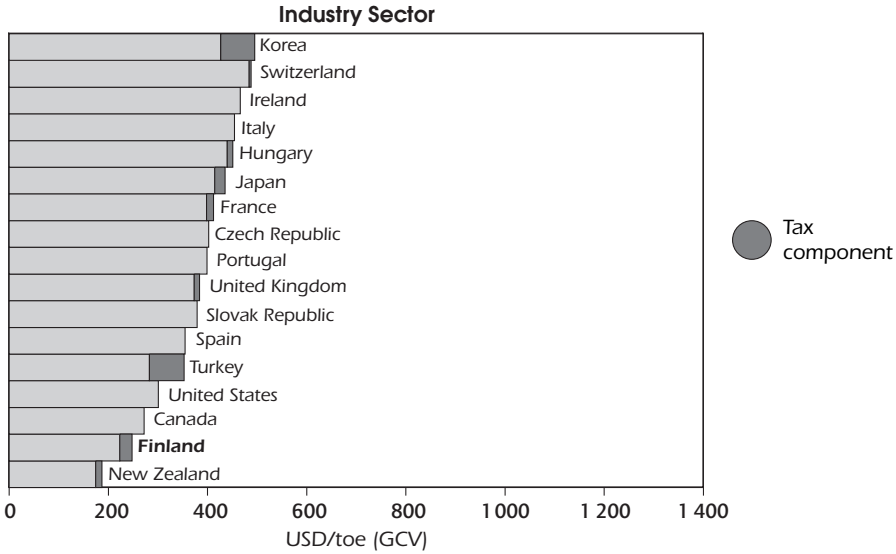
CRITIQUE

Finland, like many IEA countries, faces the challenges of heavy reliance on imported fossil fuels. Apart from domestic peat, the country relies on imports for nearly all its fossil fuel requirements, most of which come from Russia. Security of fuel supply is therefore a major concern in Finland – and the government makes it a top priority. The country holds more than its required level of oil stocks – a model for IEA countries – and is taking on more than its fair share of the oil stock burden. Gas security is maintained through fuel switching. To reduce its fossil fuel import requirements, the country is expanding its nuclear industry, and already uses domestic biomass to a large extent. Given the country's relatively small size and isolation, the government is focusing more on fuel diversity than on costly, new import pathways that could diversify supply sources. Nevertheless, it is also exploring the possibility of natural gas imports from the Baltic States and other alternative routes. Finland also makes extensive use of combined heat and power, which improves energy efficiency and lowers import needs. In general, the country is working to address the challenges it faces, while there are also areas where greater attention or modified policies would benefit overall energy and environmental policy goals.

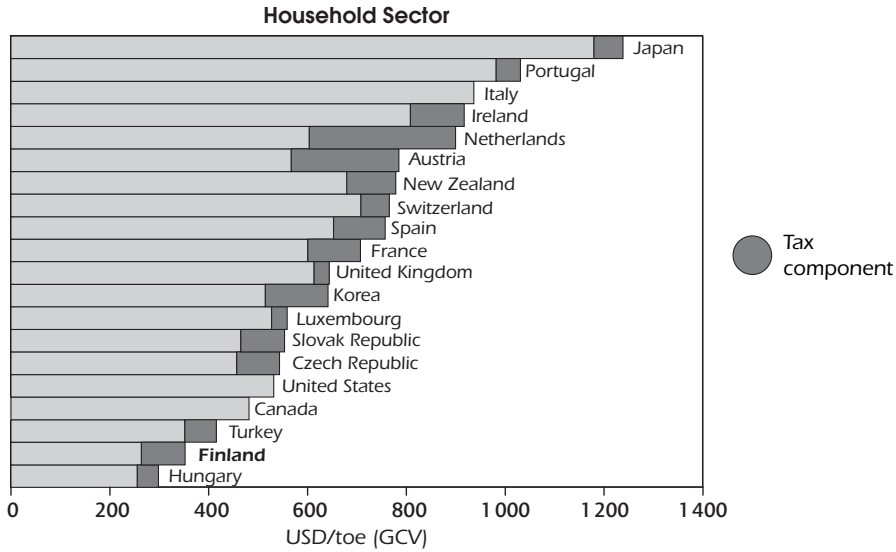
In addition to relying on domestic biomass to reduce its import dependence, Finland sees continued use of peat as a means to enhance supply security. To that end, the government has established an interim support scheme for large peat-fired conventional power plants, paying them a premium above the market price for electricity the size of which depends on the price of coal and on the price of permits under the EU-ETS. As a domestic resource, it is understandable that the government would like to support its use to prevent greater reliance on imported fossil fuels. The heavy reliance on a single country for the vast majority of fossil fuel imports further underscores the need to move away from imported fossil fuels. Nevertheless, the subsidies for peat directly undermine Finland's other major policy goal, to reduce CO_2 emissions. Even coal, which is the most obvious competition for peat, has lower CO_2 emissions and can be co-fired with biomass. The European Union emissions trading scheme is designed to make the environmental impact of fossil fuel combustion transparent and to create incentives to move towards less carbon-intensive fuels. The peat subsidy scheme directly counteracts that policy, and also undermines the country's other environmental policies. The security of supply benefits of peat use are relatively small. Biomass, a domestic

Figure 11

Gas Prices in IEA Countries, 2006



Note: Tax information not available for the United States. Data not available for Australia, Austria, Belgium, Denmark, Germany, Greece, Luxembourg, the Netherlands, Norway and Sweden.



Note: Tax information not available for the United States. Data not available for Australia, Belgium, Denmark, Germany, Greece, Norway and Sweden.
Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2007.

resource, and coal, where a well-diverse and competitive supply market exists, are both competing fuels with lower CO_2 emissions and similar benefits for security of supply. Furthermore, expanded use of nuclear has large benefits to security of supply with no CO_2 emissions. The premium tariff scheme is currently scheduled to sunset at the end of 2010, and the government should not extend the scheme any further.

Security of gas supply is a major concern as Finland is supplied by just one company and through one pipeline. To that end, security of gas supply is based on alternative fuels, such as oil or propane-air. The government policy is to maintain large security stockpiles of oil, coal and peat; large users need to hold stocks of alternative fuels equivalent to 90 days of consumption. The government also holds additional stocks of fuel oil. Overall, the government has a security of supply objective to hold five months of imported fossil fuels. We commend this proactive strategy to deal with fossil fuel security issues, particularly with respect to natural gas. Nonetheless, as gas consumption is still increasing over the longer term – and, more importantly, as peak winter demand is now close to the maximum capacity at the Russian border – the adequacy and implementation of relevant acts and decrees should be monitored to ensure continued compliance. While contingency plans may be in place to insure against supply disruptions, many countries have struggled with implementing emergency plans. For example, interruptible contracts are often used in electricity as a means of ensuring supply security. However, because these contract provisions have often existed but have never been exercised, energy users are often ill-equipped to handle supply disruptions when they occur for the first time.

It is worth noting that Finland's direct connection to its gas source might offer some supply security benefits that do not exist elsewhere in Europe. The lack of transit issues removes one source of uncertainty in gas supply, and Russian gas deliveries have been very reliable for 25 years. Supply disruptions caused by technical failures have been rare and short. Other countries in Europe suffer from being at the end of the gas supply chain; there is always the possibility that supplies for these countries could be more limited when overall supply is tight. On balance, Finland's supply security provisions are prudent and responsible, but may benefit from occasional testing of fuel switching capability.

The government has expressed interest in a possible gas connection to Baltic countries. Such a connection would help diversify sources of supply, particularly with the added possibility to draw on storage in Latvia, and also – in the long term – to bring more competition to the Finnish market. Such a connection would integrate Finland with the pan-European gas network, lessening Finland's current isolation from that market. Furthermore, one option currently being explored could bring small ships of LNG to the Finnish market, helping diversify imports. Any market solution, however, faces the

reality of the lower prices of the direct imports of Russian gas. On the other hand, this advantageous situation may not be sustainable for the long term in a liberalising and integrating market in Europe, where development of competition and rising concerns about security of supply are triggering market change. Regardless of the option or options explored or selected, the government should ensure that no undue regulatory barriers exist in Finland for new import infrastructure to be developed.

Compared to its neighbours, Finland has a relatively high share of oil used for space heating. We are pleased to note the policies in place to counter this trend, particularly the tax policies discussed in Chapter 2. Furthermore, if stronger building code standards are put in place as discussed in Chapter 4, there will be a natural drive to shift away from oil for heating, as some households switch to electric heating given significantly reduced heating needs.

RECOMMENDATIONS

The government of Finland should:

- *Adhere to the timetable to phase out the interim peat subsidies in 2010.*
- *Continue to monitor and enforce compliance with gas security of supply regulations, taking due account of any potential increase in gas consumption, especially peak demand.*
- *Examine opportunities to create new international gas connections, taking into account short- and long-term benefits to diversity of supply and competition, and ensure that there are no undue regulatory barriers in Finland for developing these options.*
- *Continue efforts to reduce the use of oil for space heating.*

As a member of the Nordic electricity system, Finland is part of a well-functioning, competitive market. It also relies on imports from Russia and Estonia and is, in general, a net importer. Unlike its neighbours, Finland's domestic resources rely to a relatively large extent on nuclear – and the share of nuclear is set to rise in the coming years – and less on hydro. It also relies heavily on biomass CHP and CHP generally. The country has limited domestic congestion, but is working to expand transmission capacity at its borders in preparation for its new domestic capacity, among other things.

CAPACITY, GENERATION AND DEMAND

CAPACITY

Finland's total capacity is just over 10 GW. As shown in Table 13, total capacity is relatively well diversified, in both ownership and fuel type. Nuclear makes up the largest share of capacity, just over a quarter. It is followed by coal and hydro, which have under a quarter each of the total. CHP has just over 20%, split between different fossil fuels, though predominantly biomass. Just under 5% of capacity comes from oil, with small amounts coming from condensing gas plants (most gas is used in CHP plants) and a negligible amount of wind (12 MW).

New capacity

As discussed in Chapter 8, Teollisuuden Voima (TVO) is currently constructing a fifth nuclear power unit on the Olkiluoto site. It will add 1 600 MW of capacity and is expected to come on line in 2011 or 2012. TVO is also considering building a sixth nuclear unit on the same site. In addition, retrofitting of existing hydro facilities and replacement of CHP plants in district heating and industry will add to capacity.

GENERATION

As shown in Table 14, as well as Figure 3 in Chapter 2, nuclear power makes up a third of Finland's electricity generation, a share that is expected to rise slightly by 2020 owing to the nuclear units now under construction. Hydro accounts for a fifth of generation, followed by natural gas (16%), biomass (14%), coal (excluding peat, 10%) and peat (6%). Oil has a small share (1%) of total generation. The new wind facilities built in Finland contribute 0.2%

Table 13

Generating Capacity by Ownership and Fuel, 2005

Unit: MW	*Nuclear*	*Coal*	*Hydro*	*CHP*	*Oil*	*Gas*	*Wind*	*Total*	*Share*
Fortum Power and Heat *Also has shares in TVO's nuclear capacity (458 MW), Kemijoki's hydro capacity (642 MW) and TVO's condensing coal-fired capacity (308 MW)*	976	1 000	755	843				3 574	35%
Teollisuuden Voima (TVO)	1 720	565						2 285	22%
Pohjolan Voima (PVO) *Also has shares in TVO's nuclear capacity (977 MW), condensing capacity (257 MW) and CHP capacity (398 MW)*		477	409	343	370	238	12	1 849	18%
Helsingin Energia *Also has small shares in nuclear, hydro and wind power*		380	45	630	118			1 173	11%
Kemijoki			1 006					1 006	10%
Tampereen Sähkölaitos				336				336	3%
Total	**2 696**	**2 422**	**2 215**	**2 152**	**488**	**238**	**12**	**10 223**	
Share of total	26%	24%	22%	21%	5%	2.3%	0.1%		

Source: Country submission.

of total generation. Most fossil fuel generation comes in the form of CHP, though there are some oil, coal and natural gas condensing power plants. Overall, generation is expected to grow by over 40% between 2005 and 2020, to almost 100 TWh.

Table 14

Electricity Generation by Fuel, 1970 to 2005

Unit: TWh	*Nuclear*	*Hydro*	*Natural gas*	*Biomass**	*Coal (excl. peat)*	*Peat*	*Oil*	*Solar, wind, etc.*	*Total*
1970	0.0	9.3	0.0	0.0	4.4	2.2	6.1	0.0	22.0
1980	7.0	10.2	1.7	0.0	12.6	4.8	4.4	0.0	40.7
1990	19.2	10.9	4.7	0.0	10.0	7.9	1.7	0.0	54.4
2000	22.5	14.7	10.1	8.9	9.2	4.0	0.6	0.1	70.0
2001	22.8	13.2	11.6	8.7	11.3	6.2	0.7	0.1	74.5
2002	22.3	10.8	11.3	10.1	13.3	6.4	0.6	0.1	74.9
2003	22.7	9.6	13.9	10.2	19.4	7.3	0.9	0.1	84.2
2004	22.7	15.1	12.8	10.6	17.1	6.5	0.6	0.1	85.8
2005	23.3	13.8	11.3	9.7	7.2	4.5	0.5	0.2	70.6
Share in 2005	*33%*	*20%*	*16%*	*14%*	*10%*	*6%*	*1%*	*0.2%*	
2010	24.7	13.8	13.3	11.9	13.6	9.0	0.8	0.5	87.6
Share in 2010	*28%*	*16%*	*15%*	*14%*	*16%*	*10%*	*1%*	*0.5%*	
2020	34.6	14.3	16.4	13.1	11.4	8.2	0.6	1.1	99.7
Share in 2020	*35%*	*14%*	*16%*	*13%*	*11%*	*8%*	*1%*	*1.1%*	

* includes industrial and municipal waste.

Sources: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2007 and country submission.

DEMAND

Just under one-half of final consumption of electricity is in the industrial sector, with 19% each in the residential and transport sectors. Though lower than in neighbouring Norway and Sweden, this high share of electricity

consumption in the residential sector is largely accounted for by the somewhat higher use of electricity for space heating. Other sectors, including commercial sectors, account for 14% of final consumption of electricity. These shares are expected to remain mostly steady through 2020, though industrial consumption is expected to rise sharply to account for 55% of the total.

Peak demand for electricity reached a record 14 776 MW on 19 January 2006. Peak demand can exceed capacity because of Finland's heavy integration with neighbouring markets.

MARKET DESIGN AND REGULATION

REFORM AND REGULATION

Reform of Finland's electricity market began in 1995 with the Electricity Market Act. The last major market reform was completed in late 1998, when small-scale customers were freed from the requirement to use hourly-metering equipment. Freedom from this requirement meant they could stay in the same grid tariff class; previously there was a *de facto* tariff for switching retailers the first time. The market is now fully liberalised, with transmission fully unbundled from the other parts of the industry, all customers free to choose their own supplier and a regulator in place to oversee market operations. As discussed in Chapter 2, the Energy Market Authority regulates electricity network operations and supervises the emissions trading. It is responsible for regulating 90 distribution network operators, 13 regional operators and one transmission system operator, Fingrid. It is also tasked with the supervision of 70 electricity retailers with supply obligations.

Regulation since 1995 requires that generation, transmission, distribution and retail sales be account unbundled. Furthermore, since 2007, network operations must be legally unbundled from other activities, with functional unbundling required for larger networks. In fact, transmission is fully independent in Finland.

MARKET DESIGN

Finland's electricity market is part of Nord Pool, the Nordic electricity exchange that also includes Norway, Sweden and Denmark. In addition to being the platform for exchange of hourly physical and financial contracts for electricity, including spot and futures contracts, Nord Pool provides several other services. It manages credit clearing for financial transactions and also operates an emissions trading market for EU-ETS credits. For more information about Nord Pool's main markets, see Box 3.

Box 3

Overview of Nord Pool Markets

Nord Pool organises four markets: Elspot, Elbas, Eltermin and Eloptions.

Elspot is the market for physical trading of electricity for delivery the following day. The price is determined on the basis of the total quantity of electricity the participants announce that they will be buying and selling. Prices for sales and purchases are determined hourly throughout the next day. The system price is the market-clearing price for the aggregate supply and demand curves, assuming there is no congestion in the system. Elspot determines the system price (the so-called reference price) both for the financial market and for the rest of the power market. Area prices are established taking into account congestion in the Nordic transmission system.

Elbas is a continuous physical market for balance purposes, namely trade in electricity up to two hours before delivery. This market is only available to Swedish, Finnish and Danish participants, and is not used by the Norwegian system operator. In Sweden and Finland, Elbas is a supplement to Elspot. The administration for the Elbas market is in Helsinki. Liquidity in this market is very low.

Eltermin is a financial market for price hedging and risk management when buying and selling electric power. The market currently consists of futures contracts, forward contracts and contracts for difference. Participants can hedge purchases and sales for up to five years. The difference between the two contract types lies in the form of settlement during the contract's trading period. For futures, the value of each participant's contract is calculated daily, on the basis of the difference between the price set in the contract and the system price. Forward contracts do not have cash settlements prior to the beginning of the delivery period. Contracts for difference provide opportunities for adjusting and hedging portfolios in terms of differentials between the system price and the various area prices in Elspot.

Eloptions is part of Nord Pool's financial market and is an important instrument for risk management and for forecasting future income and costs related to trade in power contracts. Trade in power options gives the right to buy and sell an underlying instrument for a specific underlying period. The power options offered by the power exchange are standardised and thus have clearly defined conditions. The market was established in October 1999.

Nord Pool also operates markets for exchange-traded and over-the-counter carbon credits and for green certificates for electricity, as well as offering credit-clearing services.

Source: *Energy Policies of IEA Countries: Norway 2005 Review*, IEA/OECD Paris, 2005.

Electricity generation is dispatched according to a single market-clearing price. Capacity bids into the Nord Pool market and, transmission constraints permitting, the lowest-priced capacity is dispatched in each hour until total demand is met. The price of the last unit taken – the so-called marginal supplier – sets the price for all generation during that hour.

The Nordic market is split into six market zones, with Finland considered a single zone for market purposes. If congestion arises within Finland, it is managed using domestic counter-trade and balancing power. When transmission capacity is limited across Finland's international borders within Nord Pool, Nord Pool allocates the capacity using implicit auctions. The transmission line with Estonia is a merchant line; there is no open access. However, the use-it-or-lose-it principle is applied. Transmission capacity on the import line from Russia is allocated on a *pro rata* basis, not according to market-based mechanisms.

Fingrid, the transmission system operator in Finland, purchases ancillary services. It runs the market for balancing services and also procures other balancing products and services out of the market through less transparent methods. One unique feature of Fingrid's procurement strategy is that it contracts with industrial users to provide frequency reserves. Fingrid also owns and operates its own open-cycle gas turbines (OCGTs) for balancing services. It is in the process of constructing an additional 100-MW OCGT. When this plant is completed, Fingrid will own 7% of Finland's installed net capacity.

Network regulation

The network tariff regulation model was changed in 2005. A case-by-case *ex post* model had been in place, but was replaced by partial *ex ante* regulation. The Energy Market Authority re-evaluates its pricing methodology every four years. After the regulator sets the pricing methodology, the regulator confirms the actual and reasonable profit for each operator during the entire period. The system will be further modified in 2008; the new model will also include incentives for effectiveness in investments, along with some other minor modifications.

The pricing methodology uses economic benchmarking according to a limited bonus-malus system, where operators are allowed to charge up to a limit set by a predetermined formula. The economic regulation provides incentives for reduced tariff rates, while still setting minimum quality standards. The bonus-malus system applies only to controllable operating costs; depreciation, uncontrollable operating expenses and a reasonable rate of return are

determined according to a regulated formula. Tariff rulings can be appealed to the Energy Market Authority's internal court, and, at a higher level, to the Supreme Administrative Court.

Regulated peak reserve power

To ensure security of supply, Fingrid is tasked with regulating peak reserve power. Under the terms of the *Security of Supply Act* of 2006, in force from December 2006 until February 2011, Fingrid has designated three power plants with a combined capacity of 600 MW as necessary to maintain security of supply. These plants were designated according to an open tendering procedure and the agreements between Fingrid and the three plants run through to the end of February 2009. (Plants were not required to be offered through the tender.) These plants, which are not owned by Fingrid, are older plants that had been mothballed, though not decommissioned. According to the detailed terms for operations of the units, during winter months these plants are required to offer their capacity into the market when certain peak load conditions related to capacity – not price – are met. The terms of the system are regulated *ex ante* by the Energy Market Authority according to published terms. When these peak load conditions are met, the plants are bid into the system by the owners and the bids must not be above a floor price. The floor price is determined according to a formula that includes the estimated variable costs of a conventional oil-fired power plant, including fuel and emission permit prices. As with all power plants, the bids are placed in the bid stack and dispatched according to their merit order, and if they are the last unit dispatched, they will set the market-clearing price for all power plants. Additionally, the plants can be started by Fingrid on 12-hours notice if and when the grid operator deems it necessary. Under these circumstances the power may be offered into the Elbas or real-time balancing markets, or paid according to a direct agreement with Fingrid.

Under the terms of the regulation, power plants called on through this arrangement are paid the extra costs directly by Fingrid. Fingrid pays to the plant owners the costs (based on the associated tendering process) that are incurred by keeping these plants in operation during winter periods instead of shutting them down. The system is financed through dedicated fees collected from transmission users and costs about EUR 10 million per year. As directed by the regulation, half the costs are allocated to electricity transmission from Russia and Estonia, and half to the transmission service in the main grid tariff.

This peak power load arrangement has been used once, during a cold-weather snap in February 2007.

After the winter period, from 1 March of each year, plants can be called into service with a notice period of one month, as the plants are generally not

staffed in the off-season. The power plants will again go into a starting readiness of a maximum of 12 hours from the beginning of the next winter period, on 1 December.

INDUSTRY STRUCTURE AND OPERATIONS

While activities across the electricity supply chain must be unbundled – through account, legal or functional unbundling – there is significant cross-ownership across all activities.

GENERATION

As shown in Table 13, five companies dominate Finland's domestic market. In most circumstances, however, the larger market of the four Nordic countries is the relevant market area when looking at market concentration, particularly as Finland is a net importer of electricity. In this context, Finland's capacity and generation both make up 17-18% of the total. In some cases, cross-border congestion can isolate Finland, raising the ability of its dominant generators to exert market power.

TRANSMISSION AND CONGESTION

Finland's transmission system is owned and operated by Fingrid. It is owned collectively by the State of Finland (12%), Fortum (25%), PVO (25%) and a consortium of insurance companies (38%). Fingrid began its operations in 1997; it was a new company formed by purchasing the assets of IVO (now part of Fortum) and PVO. Fingrid has 4 100 km of 400-kV transmission lines, 2 350 km of 220-kV transmission lines, 7 500 km of 110-kV transmission lines and 106 substations (see Figure 12).

There is limited congestion within the domestic Fingrid network; the absence of locational marginal pricing (LMP) within Finland means that internal congestion is not reflected in price differentials.

Interconnection capacity and congestion

Finland is well integrated with its neighbours, with 1 950 MW in both directions with Sweden, 100 MW in both directions with Norway, 350 MW in one direction from Estonia (the line was energised on 1 January 2007) and 1 460 MW in one direction from Russia.

While significant, though normal, levels of congestion are found throughout the major interconnections in Nord Pool, Finland's interconnections are

Figure 12

Map of Finland's Transmission Grid, as of 1 January 2007

Note: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the IEA.

Source: Fingrid.

relatively free from congestion. The Finland-Sweden interconnection, for example, was fully congested only 7% of hours in 2006 and only 1% of hours in 2007 through September. However, owing to the forthcoming expansion of capacity from the new nuclear unit at Olkiluoto and for other reasons, a new sea cable connection between Sweden and Finland, Fenno-Skan 2, is being constructed. It is expected to go on line at the end of 2010, increasing transmission capacity from Sweden to Finland by 500 MW and from Finland to Sweden by 800 MW.

DISTRIBUTION

There are 89 distribution network operators. The four largest are:

- Fortum Sähkönsiirto Oy (owned by parent company Fortum) has about 572 000 customers, delivering 9.9 TWh of electricity (46% by volume). It was formed from the combination of Fortum Sähkönsiirto Oy and Fortum Espoo, formerly E.ON Finland Oyj.
- Vattenfall Verkko Oy, which is fully owned by the State of Sweden, has about 370 000 customers, delivering 5.4 TWh of electricity (25% by volume).
- Helen Sähköverkko, the city of Helsinki, has about 328 000 customers, and delivers about 4.3 TWh of electricity (20% by volume).
- Tampereen Sähköverkko Oy, the city of Tampere, has about 122 000 customers, delivering 1.9 TWh of electricity (9% by volume).

RETAIL

Retail market supplies are generally integrated with distribution companies, though account unbundling is required. There are about five electricity retailers with a market share larger than 5% (by volume) and large retailers with more than 100 000 customers have been legally unbundled. The market share of the three largest companies in the retail market for small and medium-sized customers has been 35-40%. The three largest companies are Fortum Markets Oy (Fortum is the parent company), Vattenfall Sähkömyynti Oy (fully owned by the State of Sweden) and Helsingin Energia (owned by city of Helsinki). As retail electricity businesses are not required to hold any licence or report their sales, there is no detailed statistic on retail sales.

Some large foreign players have entered the Finnish retail supply market by acquiring local electricity companies. These companies are active both in electricity retail supply and in distribution businesses, and also own electricity generation in Finland. In the electricity retail supply market the share of these companies is about 20-25%.

About 70 electricity retail suppliers have an obligation to supply in Finland. In addition, there are a few electricity retailers in the market that act only in the competitive part of the retail supply market and are fully independent from network companies, though the market share of these companies is quite small.

Customer switching

Within the Nordic electricity market, customer switching is generally high in Norway and Sweden, but lower in Finland and Denmark. Past studies have shown that 11% of customers had changed their supplier at least once by 2004, with the number of customers switching rising progressively each year. When contracts that have been renegotiated with the same supplier are included in the total, the volume of electricity sold by suppliers other than the local supplier with the supply obligation or sold through renegotiated contracts in 2005 was 30% for small and medium-sized customers and 79% for industrial customers (see Table 15). A 2007 survey by the Energy Market Authority shows that 3% of small and 8% of large Finnish customers switched their supplier in 2006. In total 130 000 customers switched supplier in 2006.

There are no maximum limits governing customer switching and the Energy Market Authority does not collect data on the average time required for customer switching. Retail companies are currently working to co-ordinate and modernise their switching technology and protocols.

Following complaints about transparency concerning retail market services, in February 2006 the Energy Market Authority launched a public website for customers to compare tenders for retail electricity providers. About 1.5 million comparisons have been done in the first 12 months of the site's launch.

Table 15

Retail Customer Switching by Volume, 2001 to 2005

	Share of customers having changed supplier or having a negotiated contract (by energy volume)		
	Small to medium industrial and business	Very small business and households	Total
2001	77%	24%	56%
2002	78%	26%	55%
2003	79%	28%	57%
2004	82%	30%	59%
2005	79%	33%	59%

Source: *Annual Report to the European Commission*, Energy Market Authority, Table 7, p.43, July 2007.

While the retail market is fully liberalised with respect to price and retailers can charge any price for retail supply, market regulations require that retailers send customers a letter one month in advance of any future price changes.

Demand response

Finnish retail and distribution companies have a long history of offering different tariffs for daytime and night-time periods for interruptible load, developed especially for households with electric heating. Distribution companies are obliged to offer these tariffs to their customers. However, liberalisation of the electricity market has reduced the use of these tariffs for interruptible load since the grid equipment cannot recognise who the supplier for electricity is. Currently, there are also some suppliers that offer products with flexible prices for retail customers. However, these suppliers have reported very low levels of demand for these products at the retail level.

The government is working to enhance demand response instruments at the retail and distribution level. MEE has begun its own work in order to facilitate demand response instruments. The working group began in March 2007 and will give its recommendations in November 2008. The working group is also investigating legal and practical obstacles for demand response instruments.

PRICES

NETWORK CHARGES

Estimated 2007 network tariffs are shown in Table 16, indicating that they have increased on average by 0.5% from 2006.

Table 16

Estimated Network Charges as of 1 January 2007

	Number of regulated companies	*Approximate network access charge* (EUR/MWh)*		
		Large commercial customer	Small commercial customer	Household customer
Transmission	1	2.25 (average)		
Distribution	89 (plus 13 regional companies)	11.73	28.37	37.63

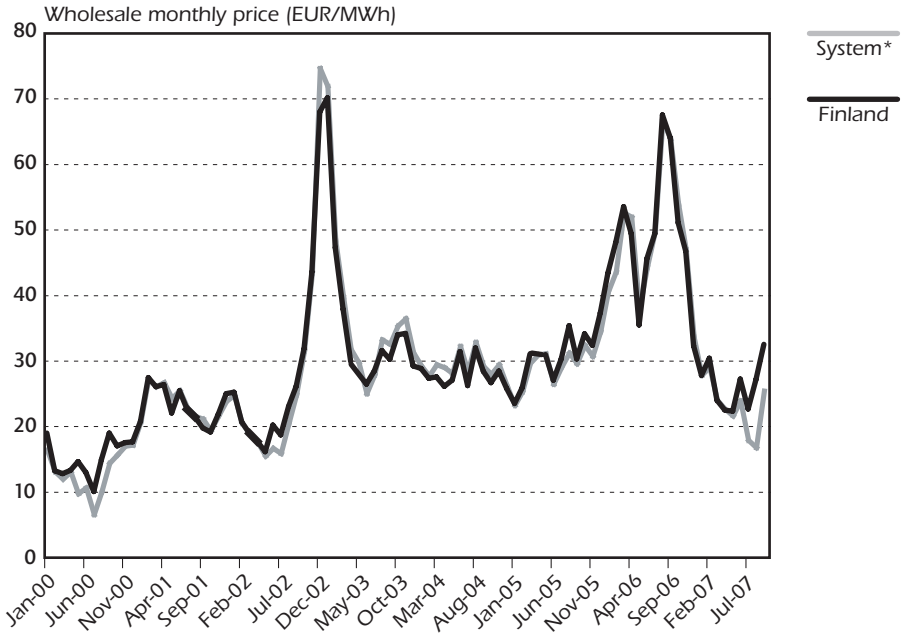
* excludes all taxes and VAT.
Source: *Annual Report to the European Commission*, Energy Market Authority, Table 3, p.26, July 2007.

WHOLESALE PRICES

Given the large amount of hydro in the Nordic electricity system, prices are very variable, even on a monthly basis. (Markets with traditional capacity-constrained fuel mixes will see less seasonal variability, though more short-term variability, in general.) As shown in Figure 13, prices in Finland in late September 2007, for example, are down 50% from the previous year, owing to better hydrological conditions and lower emission permit prices. Prices in 2007 in Finland are about 15% higher than average 2001 prices, but still much below the high 2005 and 2006 prices.

Figure 13

Wholesale Nord Pool Prices, 2000 to 2007



* No trades of physical power are conducted at this price, but it is used as a reference price in financial trading. This is the price that would result if there were no transmission constraints in Nord Pool.

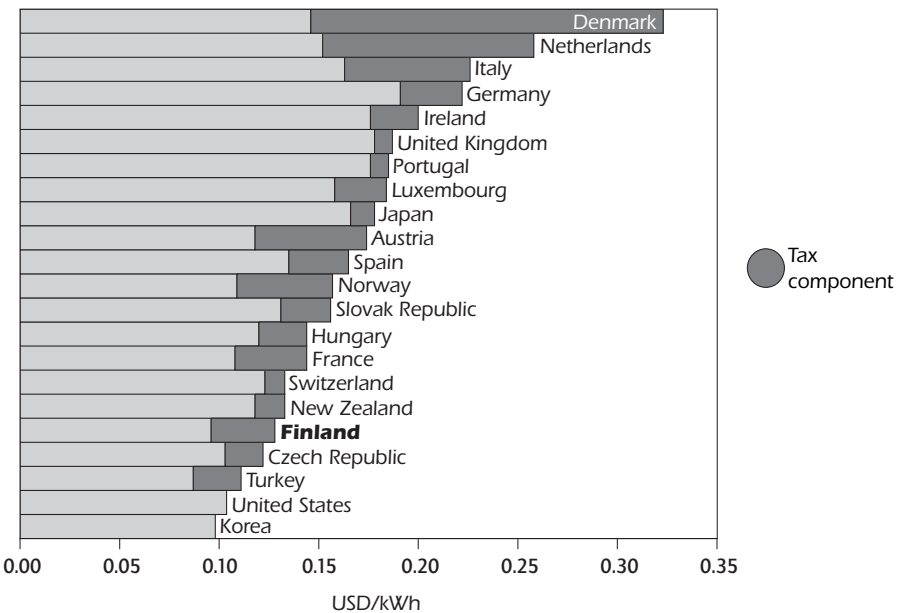
Source: Nord Pool.

RETAIL PRICES

Retail prices in Finland are low compared to other IEA countries (see Figure 14). According to the Energy Market Authority, retail prices rose by an estimated 14% between January 2006 and January 2007. However, prices have not been increasing steadily, rather they have been fluctuating. The price for carbon emission allowances dropped sharply in early 2006, resulting in sharply lower electricity prices as well. Droughts in the summer of 2006 also raised prices in the Nordic markets, though the price rise was tempered by rains later in 2006, but too late to impact retail prices.

Figure 14

Household Electricity Prices in IEA Countries, 2006



Note: Tax information is not available for Korea. The price excludes tax for the United States. Data are not available for Australia, Belgium, Canada, Greece and Sweden.

Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2007.

CRITIQUE

As part of the Nordic electricity system, Finland is a member of one of the most advanced electricity markets in the world. The government is committed to a competitive market with limited government interference. The network regulator, the Energy Market Authority, is fully independent from the

government, giving confidence to existing market participants and potential new entrants. The power grid is open to all competitors on an equal footing, encouraging new entry and reassuring investors for the long term. The Nord Pool market is highly dependent on hydro, and as such is vulnerable to drought conditions. In recent years, droughts have become more common and, in general, the Nordic market has performed well, with customers modifying their demand in relation to prices and electricity flowing to areas where it is most highly valued. In general, the Finnish electricity market operates competitively and gives signals to investors to invest when and where necessary.

Building on this considerable success, there are a few areas where policy changes could improve the market. The most important is to monitor and evaluate long-term security of supply. Although the market provides signals to develop new capacity when it is required, the government should continue to monitor infrastructure development. A sound system is in place for development of transmission capacity, particularly cross-border interconnection capacity, and we commend Finland for its continued and positive role in this collaborative and successful process. With respect to Fingrid, the transmission system operator, the regulator should continue to ensure that the grid's ownership structure – where the two largest suppliers own half of the grid – does not inhibit the grid from being operated in a fair and fully independent manner.

While greater capacity and transmission are important means of providing security of supply, it is often less expensive and more sustainable to do this through enhanced demand-side participation in the market. As for all countries, we encourage Finland to maximise the ability of customers to respond to price and invest in energy efficiency. One means of responding to price is through customer switching. Finland enjoys relatively high levels of retail switching, though lower than in Norway and Sweden, and efforts are being made to further increase this level. Retail companies are working to co-ordinate and modernise their switching technology and protocols. The government should consider setting a maximum time for customer switching, as is done in Norway and Sweden. The government is also working to enhance retail price transparency, launching a price comparison website in 2006 that has already been actively used. The ability of the demand side to respond to price and seek out lower- or better-priced competitors is the best means of ensuring competitive electricity prices over the long term. We therefore encourage the government to continue efforts to expand these activities and make retail competition a more prominent part of sector regulation.

Along these same lines, customers should also be able to respond to price in the shorter term. One means of doing this is through metering infrastructure that allows customers to respond actively or passively to price changes. Retail providers in Finland already give customers various contract options that

create incentives to reduce consumption during peak price periods. Nevertheless, the government has already undertaken efforts to further enhance customer access to time-varying prices and other demand response instruments. We are very pleased to note these efforts. In particular, we encourage the government and regulator to continue to monitor the prospects for greater use of smart metering for residential and commercial customers, ensuring that retailers and distribution network operators have the right incentives to roll out the necessary equipment if it is cost-effective to do so.

Finally, Fingrid's activities regarding emergency peak power procurement under the 2006 *Security of Supply Act* cause more serious concerns. It is understandable that the government would like to ensure security of supply in light of concerns about imports and decommissioned domestic plants. However, setting up emergency generation creates the danger that such a policy will discourage market investment as prices are suppressed, requiring continued government interference. Furthermore, the scheme is designed primarily as a stopgap measure to deal with capacity constraints in the interim, before the new nuclear unit at Olkiluoto goes on line. Such a clear stopgap measure severely hinders the market from giving investors the right signals to invest for the long term and on a continuous basis. In fact, the existence of this measure sends a signal to investors that any sense of future supply insecurity will be met with government action – so private investors need not and, from an economic perspective, should not invest. Instead, Finland should continue to rely on cost-reflective prices that reflect scarcity and send signals to investors about when to build new capacity. More transparent pricing of reserves would also improve signals to investors. Finland's efforts to work with other Nordic countries on market-based mechanisms that enhance security without unduly distorting the market are also welcome. At the very least, the government should ensure that the emergency procurement provisions are clearly established as a short-term, interim policy with a clear termination date, and that the grid-owned generation is only bid in under emergency – not just high-price – conditions.

RECOMMENDATIONS

The government of Finland should:

- *Take measures to ensure longer-term security of supply, with particular attention paid to measures that reduce demand.*
- *Continue work to enhance retail competition through efforts to reform and streamline customer switching technology, rules and regulations.*

- *Continue efforts to further develop demand response instruments and ensure that retailers and distribution network operators have the right incentives to offer contracts and provide smart metering equipment to residential and commercial customers that allow them to respond to time-varying prices.*
- *Ensure that any emergency capacity owned or operated by the grid operator is offered into the system under conditions related to security and not price, and that this is strictly an interim solution until a mechanism that is less distorting to the market can be established in co-ordination with other Nordic countries.*

Finland has a well-developed nuclear industry, and is expanding its nuclear sector with the construction of Olkiluoto 3, the first new nuclear power plant in one of the IEA's European countries in eight years. Nuclear power makes up about a quarter of the country's electricity generation, and this will grow with the addition of the new plant, likely in 2011, taking into account existing delays. An additional sixth nuclear plant is also being considered. Finland is unique among most IEA countries in having already taken a decision-in-principle regarding disposal of high-level radioactive waste, and is currently building an underground rock characterisation facility.

OVERVIEW

The nuclear share of electricity production in Finland was about a third in 2005, with a total amount of electricity produced of 23.3 TWh. As detailed in Table 17, the four nuclear power plant units in operation are two boiling water reactors (BWRs) on the west coast of Finland at Olkiluoto, and two pressurised water reactors (PWRs) on the south coast at Loviisa.

All four units have shown high availability factors, 88.6% to 96.9% in 2006, and are planned to be in operation for at least two additional decades. The total installed nuclear capacity is 2 696 MW. For the Loviisa reactors on the south coast, a new 20-year operation licence application has already been filed that would, if granted, extend the lifetime of these two units to 50 years (until 2027 and 2030).

Table 17

Operating Nuclear Power Plants in Finland

Site	*Plant*	*Type*	*Construction start*	*Grid connection year*	*Installed capacity MW_e*	*Operator*
Loviisa	**Loviisa-1**	PWR	1971	1977	488	Fortum
	Loviisa-2	PWR	1972	1980	488	Fortum
Olkiluoto	**Olkiluoto-1**	BWR	1974	1978	860	TVO
	Olkiluoto-2	BWR	1975	1980	860	TVO

Source: IAEA PRIS database.

On 8 January 2004, TVO submitted to the government an application for a construction licence for Olkiluoto 3. The reactor is an Areva EPR 1600 with thermal power of 4 300 MW, electrical output of about 1 600 MW and a technical operating lifetime of 60 years. The granting of the construction licence took place on 17 February 2005. The construction is well under way, though with some delays, and TVO is planning to file the application for the operating licence in mid-2008. The commissioning of the plant could take place in 2010, with commercial operation beginning in 2011. The financing structure of the plant, which is principally owned by a private-sector consortium, is innovative (see Box 4). After completion of Olkiluoto 3, the nuclear share could represent one-third of Finland's electricity consumption.

The planning for a sixth reactor is under way and the utilities have begun related work on the environmental impact assessment.

Box 4

Financing Structure of Olkiluoto 3

In December 2003, Teollisuuden Voima Oy (TVO) decided to build a new 1 600 MW nuclear unit, the first nuclear power plant to be built in a liberalised market. Construction commenced in 2004 at the site of two other TVO nuclear units, Olkiluoto 1 and 2. The new unit is a third-generation European pressurised water reactor (EPR) and is being delivered as a turnkey project by a consortium of Areva and Siemens. These vendors carry, to a large extent, the risks of project delays and budget overruns. Total project costs are estimated to be around USD 3.5 billion. Olkiluoto 3 was initially scheduled to be commissioned in 2009 but, owing to construction setbacks, has been delayed until 2011.

TVO is owned by several Finnish companies. Pohjolan Voima Oy (PVO) is the largest shareholder with 60.2% of the Olkiluoto 3 shares. A majority of PVO is, in turn, owned by various companies in the Finnish pulp and paper industry; the remaining shares are owned by municipalities and municipally owned local utilities. Fortum, a partly (51.7%) state-owned utility, owns 25% of the Olkiluoto 3 shares in TVO. Another 8.1% of Olkiluoto 3 shares are owned by Oy Mankala AB, a fully owned subsidiary of Helsingin Energia (a utility owned by the city of Helsinki). The remaining Olkiluoto 3 shares are with EPV (6.6%), a regional energy procurement company owned by 21 local utilities, which are principally municipally owned. EPV also owns 8% of PVO. In total, a majority of TVO-Olkiluoto 3 is privately owned, with a large share of state and municipal ownership, through a unique ownership structure. The project is financed on the balance sheet of TVO, which implies that recourse on loans is not limited to the Olkiluoto 3 project but tied to TVO as a company. This has

allowed for 75% debt financing of the project. TVO shareholders injected subordinated debt and equity corresponding to 25% of the finance requirement.

TVO sells its output at cost to its shareholders. This innovative sales structure – which was also used by TVO for Olkiluoto 1 and 2 – is the key to allowing for the high level of lower-cost debt financing. The Olkiluoto 3 project is covered by long-term contracts that effectively pass all risks on to the shareholders. Thus, risks are spread across the underlying meshed ownership structures. This does not eliminate the real risks. The large consumers and utilities receive generated electricity at cost. If these costs cannot compete with the wholesale price of electricity in the Nordic market, the project shareholders will incur a loss compared to the alternative of buying electricity in the market or producing electricity with a more competitive technology. But the Nordic market also offers a relatively liquid financial market, which creates an opportunity for the final owners of Olkiluoto 3 to manage remaining risks – at least to a certain extent.

Source: *Tackling Investment Challenges in Power Generation in IEA Countries*, IEA/OECD Paris, 2007.

POLICY AND FRAMEWORK

A stable majority of the Finnish population supports nuclear energy. Since 1983, a series of surveys has been made by the industry, and the 2006 figures show 50% in favour and 20% against nuclear power. However, in many other surveys, a majority of the population is against a sixth nuclear power plant to meet future electricity demand. The government is not ruling out a further expansion of nuclear energy.

Nuclear energy activities are governed by the 1972 Nuclear Liability Act and the 1987 Nuclear Energy Act. The latter will be modified in 2007/08, but no major changes in basic principles are foreseen.

The Radiation and Nuclear Safety Authority (STUK) is a regulatory authority, research institution and expert organisation, whose mission is to protect people, society, the environment and future generations from harmful effects of radiation. STUK monitors the operation of nuclear plants in Finland to ensure that the licensees conduct their operation in a safe way. STUK is also involved in licensing procedures for building and operating nuclear power plants. For major nuclear facilities, the nuclear legislation defines the following three-step licensing procedure (see Figure 15):

1) Decision-in-principle, where the government makes the licensing decision, but subsequent approvals by the host municipality and the Parliament are still required.

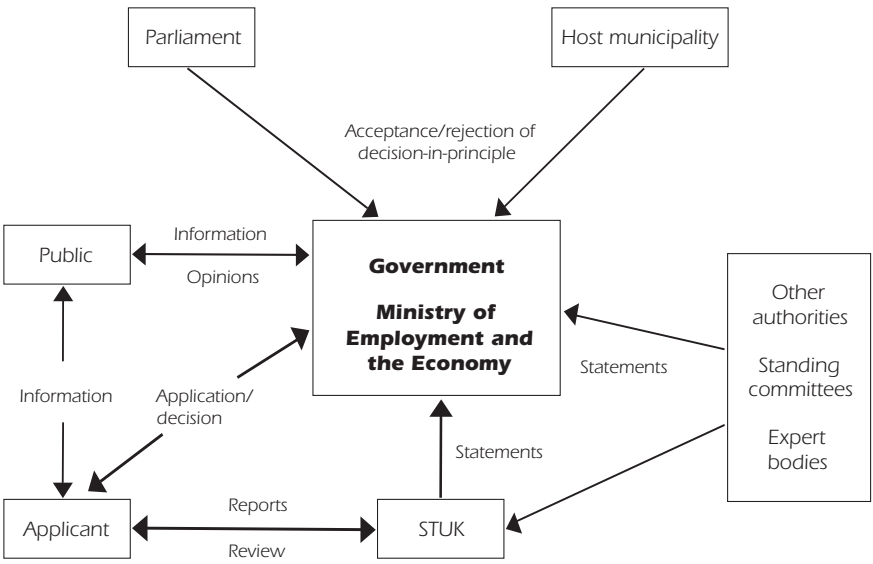
2) Construction licence, which is issued by the government.

3) Operating licence, which is issued by the government.

STUK conducts the safety-related review in each of these licensing processes and the Ministry of Employment and the Economy (MEE) prepares the licensing decisions. Minor licences for waste management operations are granted by STUK.

Figure 15

Licensing of Nuclear Facilities in Finland



Source: Nuclear Energy Agency, OECD, Paris.

FUEL CYCLE AND RADIOACTIVE WASTE MANAGEMENT

Finland buys all its nuclear fuel from international vendors since no domestic production capabilities are available.

Finland is unique in having a parliamentary decision on the site and system for a high-level radioactive waste repository. The site for the disposal facility, which

is intended to hold all high-level waste in Finland, is at Olkiluoto on the west coast. The ongoing step in the project is the construction of an underground research laboratory, ONKALO, which is intended to be a part of the final disposal facility. The planned depth for the repository is 500 metres and the fuel is to be placed in copper canisters surrounded by bentonite clay and bedrock. The disposal of the spent fuel should start in 2020, according to the 1983 decision-in-principle by the government. The waste programme cost estimate is 5% to 10% of all costs of Finnish nuclear electricity (around EUR 2.5 billion for the spent fuel disposal for five plants and about EUR 5 billion for waste handling, including the decommissioning of the facilities).

The State Nuclear Waste Management Fund is a special-purpose fund, segregated from the state budget, under the administration of MEE. It collects, holds and invests the assets of the fund. The capital of the fund is composed of annual payments by parties MEE has deemed liable for nuclear waste management. At the end of 2006, the fund held around EUR 1 500 million, which covers the entire liability for the management of spent fuel and radioactive waste generated so far and the future decommissioning of the nuclear power plants.

CRITIQUE

Finland's approach to nuclear energy, with transparency given the highest priority, is commendable. The extensive responsibilities of the utilities as expressed in Finnish law are met in an impressive way. Operation and waste disposal, as well as initiatives for construction of new nuclear units, are all carried out in a timely and effective way, and in an atmosphere of extensive international co-operation. Safe operations of generation and waste treatment facilities are given appropriate attention. The financing structure of Olkiluoto 3 can be used as a model for other countries.

The nuclear share of electricity production in Finland is about 33%, and the four existing nuclear power units have exhibited very high availability factors. The new reactor under construction, Olkiluoto 3, has been delayed by 18 months compared with the original time schedule. The substantial share of electricity supply to be provided by the new Olkiluoto 3 facility requires that the government closely follow the progress of the project.

The long-term planning of the use of nuclear energy in Finland after 2020 seems to be somewhat unclear. As part of its long-term strategies to 2050 and 2100, the government should clarify its vision to facilitate discussions on the R&D efforts required, the maintenance of necessary education and training capabilities, as well as to promote a discussion on different relevant energy mix scenarios. In line with its very transparent and sound approach, the government should continue to ensure that the effects of using different

nuclear shares in the energy mix are well understood by the public, including the safety, social, environmental, economic and security of supply effects.

Finland is unique in having a parliamentary decision on the site and system for a high-level radioactive waste repository. The long-term planning and commitment to keeping to this plan are commendable, underpinning sustained future support for nuclear power in the country, and are a model for other countries. Finland was able to reach this conclusion through a transparent process that involved consulting with and involving the public and other stakeholders, and then taking a clear decision and carrying it through. Support for nuclear power rests in part on having a stable and clear mechanism for high-level nuclear waste disposal. As Finland is well on its way to establishing a final disposal site, this will help ensure long-term acceptance for nuclear power. Finland's successful experience with site selection and other aspects of high-level radioactive waste disposal should be used as an instructive guide for other countries.

The financing structure of Olkiluoto 3, the first new nuclear power plant built in a liberalised market, is unique and innovative. With high shares of industrial electricity demand, the project is able to sell the output of the plant at cost under long-term contracts to the shareholders of the plant. As 100% of the output is pre-sold at cost, this allows for a higher level of cheaper debt financing as the risk is shared across many actors. Such a model has been used in other sectors with high capital costs – in natural gas markets in the United States, utilities often underwrote new pipeline construction through long-term gas contracts – and can serve as an example for the construction of new nuclear power plants in liberalised markets, particularly those with high industrial electricity loads.

Planning for a sixth reactor is under way and the utilities have started to perform environmental impact assessments. The authorities should, as soon as possible, start to prepare for any forthcoming applications by making careful analyses of all aspects of the decision procedure of Olkiluoto 3.

RECOMMENDATIONS

The government of Finland should:

- *Continue to conduct long-term quantitative studies assessing the effects of different shares of nuclear energy in Finland's future energy portfolio to facilitate discussions on levels and funding of related energy R&D, as well as general energy policy measures.*

- *Continue to ensure that the results of these quantitative studies inform the public on the safety, social, environmental, economic and security of supply effects of using different nuclear shares in the Finnish energy mix.*
- *Continue to closely monitor the progress of the construction of the Olkiluoto 3 unit, in view of its importance to the national security of electricity supply.*
- *Make a detailed analysis of all relevant aspects of the actual decision-making and implementation process for the Olkiluoto 3 unit in order to identify critical issues and areas for improvement, helping prepare for possible future applications.*
- *Continue international collaboration in the field of nuclear energy, for its own benefit and so that lessons learned can be disseminated to others.*

ENERGY RESEARCH & DEVELOPMENT

Although it is a small country with a limited research and development (R&D) budget, Finland has a well-developed energy technology R&D programme, particularly in certain areas. The country has stable funding for R&D, strong national and regional organisations (particularly Tekes and the Technical Research Centre, VTT) that specialise in key technology areas, active international collaboration and strong private-sector involvement in most aspects of the R&D process. It also has consistent, systematic support along the full energy R&D chain, including basic research, applied energy R&D, demonstration and assistance in financing and commercialisation and export of innovative technologies.

ENERGY R&D POLICIES

ENERGY POLICY

Technology development is one of the key activities in Finland's national energy policy. Advanced technology plays an important role in curbing energy use and energy-related emissions. In the nuclear field, the main target of the research is to promote nuclear safety. The objective of energy RD&D is to develop solutions that are competitive on the international market – the domestic market is often too narrow. Energy technology research is linked to national policies on industry, energy and technology.

In November 2005, the government adopted the *National Energy and Climate Strategy* to address necessary emissions reduction measures outlined in the country's Kyoto Protocol commitment. This strategy provides a framework for renewable energy and energy efficiency technology development and financing as key measures in achieving energy and climate policy targets. Of long-standing focus are the areas of combined heat and power (CHP), power generation by industry, distributed power generation and the efficient use of energy, a focus which the strategy strengthens. In the area of renewable energy, Finland's focus is on the efficient and clean use of various biomass resources in existing and new product concepts, including the production of liquid biofuels for transportation.

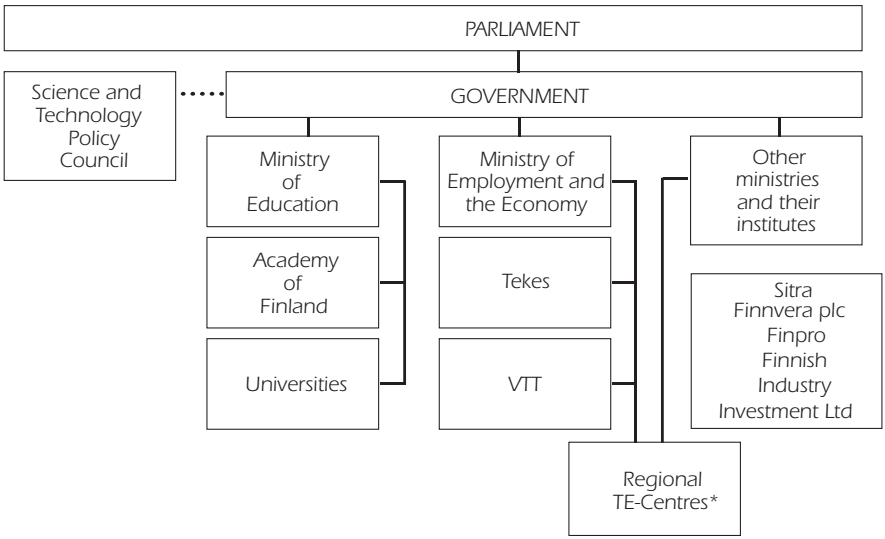
ORGANISATIONAL OVERVIEW

The organisational scheme of Finland's R&D administration is described in Figure 16. The Science and Technology Policy Council, which is chaired by the

Prime Minister, defines the primary architecture of R&D policy. The Academy of Finland belongs to the administrational branch of the Ministry of Education. The Finnish Funding Agency for Technology and Innovation (Tekes) acts under the Ministry of Employment and the Economy (MEE). VTT provides analysis and support to MEE, Tekes and private-sector actors. There appears to be strong co-ordination among the key research actors in Finland. More details about each entity are provided in the next section.

Figure 16

The Organisational Scheme of the Finnish R&D Administration



* Employment and Economic Development Centres.
Source: Ministry of Employment and the Economy.

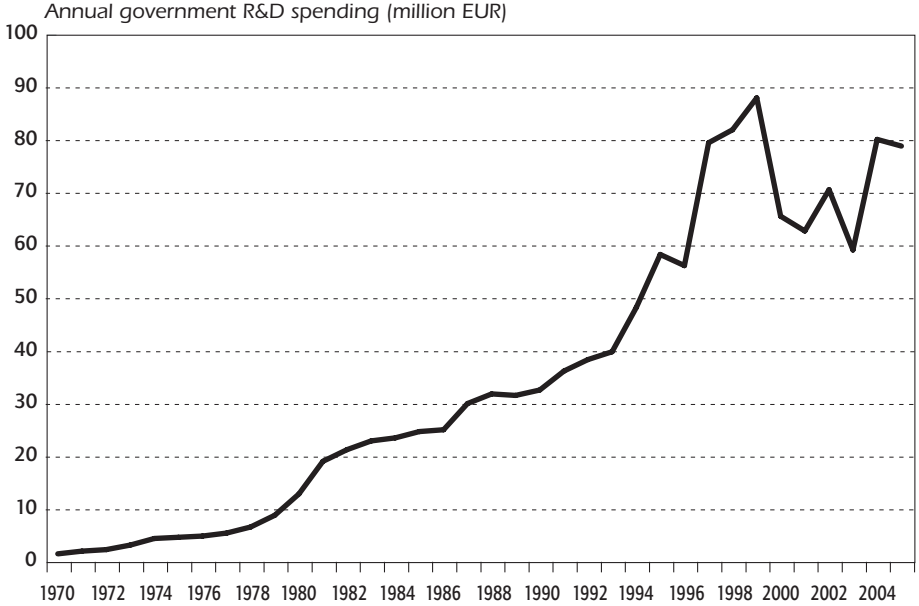
FUNDING

The major public R&D funding actors in Finland in 2005 were Tekes (EUR 448.4 million), universities (EUR 416.7 million), government research institutes (EUR 259.4 million), the Academy of Finland (EUR 223.5 million) and other organisations (EUR 246.0 million) for a total of EUR 1.6 billion, covering government R&D spending in all sectors, including energy.

As shown in Figure 17, Finland's energy R&D expenditures have grown substantially since the 1980s. Recent variations are the results of changes in large technology programmes, discussed further below. Government spending on energy research, development and demonstration in 2005 totalled EUR 78.8 million, while spending for energy-related research from public sources represented 1.3% of total Finnish R&D expenditures.

Figure 17

Government Spending on Energy Research and Development, 1970 to 2005



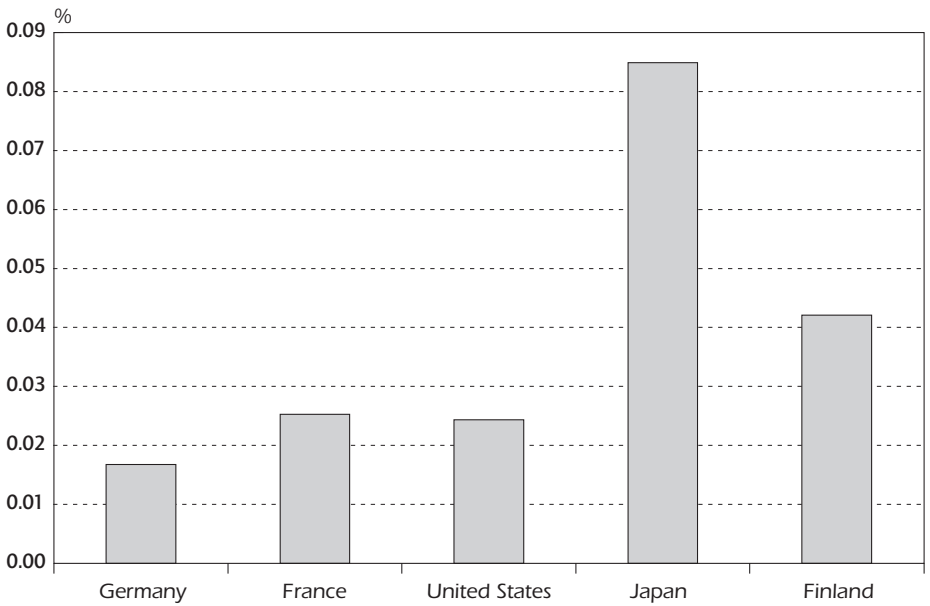
Source: Statistics Finland, *Statistical Yearbook of Finland 2006*.

The magnitude of all nuclear research activities is about EUR 30 million per year. Research funded by the national government is about EUR 6 million per year and the rest is utility-funded research activities.

The share of GDP that goes to public funding of energy R&D is rather high in Finland (see Figure 18). When nuclear research expenditures are excluded, Finland's share is the highest.

Figure 18

Expenditure on Public Energy Research as a Share of GDP in 2004



Note: Excluding nuclear research, Finland has the highest energy research spending as a share of GDP, followed by Sweden and Switzerland.

Source: Country submission.

NATIONAL INNOVATION SYSTEM

Finland has a solid track record in systematically supporting technology development through the cycle of basic research, development, demonstration and commercialisation. This innovation includes consistently involving the private sector in each stage of technology development. Energy-related R&D accounts for about 10% of the total amount spent on the national innovation system for all technologies and activities.

The government recently established strategic centres for science, technology and innovation, which focus on research that has practical application to and benefits for the Finnish economy through growth and enhanced competitiveness. The Science and Technology Policy Council of Finland has established centres for the following "cluster" areas: energy and environment, metal products and mechanical engineering, forestry, health and well-being, and the information and communication industry and services.

In these centres, the government works with companies, universities and research institutes to agree on a joint research plan that achieves practical technology application within five to ten years. Participating companies and research units are asked to provide expertise and to make a strong financial and technical commitment to the centres. To complement this, public funding organisations provide long-term funding commitments for the centres. These centres provide Finland a new way of co-ordinating dispersed research resources to meet targets that are important for the country's business and society.

ENERGY R&D ORGANISATIONS AND SELECTED PROJECTS

FINNISH FUNDING AGENCY FOR TECHNOLOGY AND INNOVATION

Tekes, the Finnish Funding Agency for Technology and Innovation, is the main public financing expert organisation for research and technological development in Finland. Its mission is to boost the development of Finnish industry and the service sector through innovations in technology. It is hoped that this innovation will renew the economy and increase value, productivity and exports, thereby creating employment and enhancing well-being. Tekes awards its funding to companies, universities and research institutes operating in Finland. It funds R&D in areas defined on the basis of clear user need, including fields such as products and business models, the environment and energy, health and well-being, services, safety and security, and work and leisure.

Funding for Tekes comes from the state budget via MEE. Tekes has a budget of about EUR 400 million, which funds about 2 000 projects annually. It channels approximately one-half of its total annual funding through technology programmes that are used to promote development in specific sectors of technology or industry, and to pass on research results to business in an efficient way.

In 2006, a total of 21 extensive national technology programmes were ongoing, with four programmes directly focused on energy (discussed in more detail below). The duration of the programmes ranges from three to five years and their funding levels range from EUR 20 million to EUR 150 million. Tekes usually finances about half of the costs of the programmes. The other half comes from participating companies and research institutes. Companies can participate via their own projects or by joining common research projects. Companies, research organisations and Tekes plan the technology programmes together. The planning takes place in working groups and at

public seminars. The Board of Tekes makes the final decision to launch a programme. Each technology programme has a steering group, a co-ordinator and a responsible person within Tekes.

Business Opportunities in Mitigating Climate Change Programme (2004-2008)

The Business Opportunities in Mitigating Climate Change Programme, or the ClimBus technology programme, promotes and finances the development of technologies and services to reduce greenhouse gas emissions. The programme started in 2004 and will run until the end of 2008, and the total ClimBus budget is estimated to exceed EUR 70 million. It focuses on areas of technology in which Finland already has solid expertise, including clean electricity and heat production through biomass, biofuels for transport and energy-efficient technologies in all sectors. The programme is designed to be flexible and to adapt to include information about future emissions reduction technologies as they are developed.

As in other areas of Finnish energy R&D, the development of services and new business concepts are emphasised in the ClimBus technology programme. Emissions trading and emissions monitoring are expected to create a demand for new services and new kinds of businesses. The programme aims to help create new business models and services as a strategy for eliminating barriers to the introduction of energy-efficient technologies.

Technology Programme for Distributed Energy Systems (2003-2007)

The Technology Programme for Distributed Energy Systems (DENSY) began in 2003 with the ambition to strengthen Finland's energy technology capability in a global market. The programme develops new technologies and business solutions by accelerating academic research projects and private R&D. Exceeding its original funding target of EUR 57 million, the programme now supports over 120 individual projects. As with most Tekes programmes, Tekes provides about half of the total funding, with the other half contributed by participating companies and other organisations.

The programme selected cross-cutting issues as focus areas, recognising that market and other barriers are often the most important challenges faced by distributed energy technologies. Tekes established topical research networks and grouped research projects into the following categories: electric systems, heating systems, CHP, business models, industrial manufacturing and advanced combustion turbines. In addition, fuel cell research targeted on energy production and energy system integration was included in the programme beginning in 2004, and in 2007 a new fuel cell technology programme was launched.

Tekes has focused more on assessing the results from large-scale testing of distributed energy systems and demonstration of new technology. More effort is now put on developing new business models, as business development is as big a challenge as technology development. Business models are implemented and tested in practical "piloting" cases – the steps, tasks, gates and milestones are monitored in order to develop methodologies and instruments that could be implemented in technology programmes in general.

Fuel Cell Technology Programme (2007-2013)

The Fuel Cell Technology Programme was launched in March 2007. The full budget for the seven-year programme is about EUR 150 million, with Tekes contributing EUR 50 million. The programme vision is that Finnish industry will develop products and services based on fuel cell technology for global markets. This will take place in co-operation with foreign technology partners, the research community and the government. The priority areas are stationary and portable fuel cell applications and specialist vehicles with fuel cell power modules.

Building Services Technology Programme (2002-2006)

Tekes launched the Building Services Technology Programme (CUBE) in 2002 with the intention of improving the energy performance and comfort of residential and non-residential buildings. The programme also aims to integrate energy services with up-to-date building features in the lighting, networking and comfort areas, and to add value for property owners on the basis of life-cycle benefits and functional space. Strategic focus areas include developing a service industry dedicated to monitoring and delivering energy efficiency and testing methods for managing the life-cycle attributes of building services. Information management and processing are also important areas of research. The CUBE programme consists of 100 projects, 25 of which are public research projects. The monetary value of projects is approximately EUR 40 million. Tekes funding represents approximately EUR 20 million. Almost 200 companies and 10 research organisations participate in CUBE projects.

Fusion technology activities (2007-2011)

Fusion funding by Tekes focuses principally on applications and technology for the International Thermonuclear Experimental Reactor (ITER) project to develop commercial fusion power. Fusion technology activities are designed to reinforce Finnish skills in the field, especially in materials studies and in developing remote maintenance systems. Strategic fusion research investment is focused on materials research and remote maintenance systems needed by fusion power systems. Finland now has a unique concentration of competence in these areas.

ACADEMY OF FINLAND

The Academy of Finland is the main public financing organisation for basic research. Its mission is also to serve as an expert body in science and science policy, and to strengthen the position of science and research in Finland. The organisation works to advance the renewal and diversity of research, and supports the extensive application of research results for the benefit of welfare, culture, the economy and the environment. Its operations cover the full spectrum of scientific disciplines. Its main focus in development activities is on the multifaceted advancement of professional research career options, the establishment of cutting-edge research environments and the utilisation of international opportunities. The Academy of Finland issues funding decisions worth about EUR 260 million, which represents 16% of government R&D spending. It has a wide range of funding instruments tailored to different purposes. Each year, its research projects account for some 3 000 researchers at universities and research institutes. The Academy of Finland operates within the administrative sector of the Ministry of Education and receives its funding through the state budget.

In the area of energy R&D, the organisation co-operates closely with other national financiers, such as Tekes and government ministries, whose role is to fund mostly applied research. This jointly funded research is an important element of the Finnish innovation environment, with additional benefits for co-operation with European research organisations.

In 2005, the Academy of Finland commissioned an international evaluation of public energy research in Finland (see Box 5), which was published in November 2006. On the basis of its findings, the Academy of Finland launched a new basic research programme on the energy field for 2008 to 2011, the Sustainable Energy Research Programme (SusEn).

Sustainable Energy Research Programme (2008-2011)

The objective of the SusEn research programme is to strengthen basic research in the energy field and to harmonise research on environment-friendly energy production with economic factors in the early stages of research. The aim is also to deepen active, basic research-oriented dialogue between researchers and industrial actors, while simultaneously creating mechanisms for rapid and effective use of new knowledge. The programme aims to support doctoral studies in fields relevant from the energy industry's point of view, as well as to increase international networking and national multidisciplinary co-operation among researchers.

Box 5

International Evaluation of Finnish Energy R&D

In an effort to improve its performance, in 2005 the Academy of Finland commissioned an international evaluation of public energy research in Finland. The primary objective of the evaluation was to determine the scientific quality of public energy research during the period of 1999 to 2005. The evaluation covered research activities carried out in universities and research institutes representing the energy field, 23 organisations in total.

Some of the key recommendations in the area of university energy research are listed below:

Greater co-ordination of research activities. Given the existing large number of university-based research groups, as compared to other countries on a per-capita basis, that are engaged in the entire spectrum of energy research, more effort should be made to co-ordinate their activities. The evaluation recommended more co-operation and co-ordination not only in the university sector itself, but also between the universities and other research units.

More permanent funding arrangements. The evaluation recommended establishing a system that provides more permanent funding for a large number of experienced, mid-career researchers.

Greater research mobility. The evaluation recommended that, in order to encourage greater mobility both from within and from outside Finland, a larger number of competitively awarded travel and visiting fellowships should be granted.

Shortening of the PhD completion period. The review urged efforts to develop much shorter doctoral training periods.

Protecting free academic research. According to the report, free academic research remains very important; the base funding component of the research budget should therefore not be reduced. The review recommended against arrangements between universities and industry that restrict the publication of research results.

Greater focus on long-term projects. Given that the majority of the projects reviewed in the evaluation focus on near-term market applications, the report recommended a greater focus on long-term projects in the area of energy R&D. In addition, such long-term projects would be a good basis for collaborative international projects on the integration of distributed generation.

Source: Academy of Finland, *Energy Research in Finland, 1999-2005,* pp. 9-10.

SusEn is an extensive research programme focused on technologies of different forms of energy production and assessment of the environmental and health effects of energy production. The programme focuses on researching and developing raw materials, technologies and processes relating to energy production and energy use, and analysing related socio-economic and political systems.

New opportunities offered by emerging technology in energy research include decentralised energy systems and large-scale production units. A number of technology solutions will be needed in order to limit greenhouse gas emissions. A key goal of the programme is to study, compare and harmonise these methods. To that end, SusEn's thematic areas include the following:

- *New technologies for energy production*. Research is principally focused on the production of biomass fuels, other carbon-free production technology (such as wind power, solar power and fuel cell technology) and on the next-generation nuclear power research and research in separating and storing CO_2.

- *Effective energy systems*. Research in this area is principally focused on energy systems, energy economy and energy markets as well as research into energy consumption, reduction of environmental and health effects of energy systems. Furthermore, research is focused also on environmental issues related to energy policy and the energy economy.

- *Efficiency of energy*. In this area, the research programme is examining supply-side and demand-side energy efficiency technologies and practices.

The programme is scheduled to run from 2008 until 2011. The board of directors of the Academy of Finland has allocated EUR 9 million for the programme, and is prepared to allocate additional funds for co-operation with other countries. Private actors are also considering investing in the programme.

To achieve its goals, SusEn will need to co-operate with other existing energy R&D programmes, including most notably Tekes's ClimBus, DENSY and fusion technology programmes. The Academy of Finland's programmes that relate to SusEn are the Research Programmes on Sustainable Production and Products (KETJU) and on Power and Society in Finland (VALTA).

The research teams receiving funding are required to report on the progress of their projects on an annual basis or in accordance with the steering group's decision, and submit a final report to the Academy of Finland upon the completion of the projects.

TECHNICAL RESEARCH CENTRE OF FINLAND

VTT, the Technical Research Centre of Finland, is a contract research organisation with about 2 800 employees providing a wide range of technology and applied research services. VTT's energy research comprises a variety of energy production technologies, ranging from nuclear to bioenergy, as well as to other renewable and environment-friendly energy production technologies. Energy economy, transfer and storage, as well as the effective use of energy and management of emissions are also part of VTT's research. In VTT's energy branch, there are over 500 research personnel, about half of all energy researchers in Finland. VTT is also a technical expert supporting government and enterprises on technical issues.

GETTING THE TECHNOLOGY TO MARKETS

INITIATIVES OF THE MINISTRY OF EMPLOYMENT AND THE ECONOMY

The Ministry of Employment and the Economy (MEE) has a financial instrument, Energy Aid, for energy investments. This instrument aims to influence the use of renewable energy and energy efficiency technologies and to decrease the environmental hazards of energy production and use. Energy Aid gives priority to projects promoting commercialisation of new technologies and can be granted to companies and other entities, including municipalities. In 2006, Energy Aid granted about EUR 34 million, of which about EUR 4 million came from the European Regional Development Fund (ERDF). About two-thirds of the allowance was granted to projects promoting new technology. The government also has the possibility to allocate money for specific large demonstration projects. MEE co-ordinates the Energy Aid programme with Tekes.

CLEANTECH FINLAND

The Finnish Innovation Fund (Sitra) is an independent public foundation under the supervision of the Finnish Parliament. It has launched a new programme, Cleantech Finland, part of its environmental programme. The purpose of the programme is to upgrade the business activities and competitiveness of the Finnish environmental and energy sector for global markets. Sitra's environmental programme contains some energy projects, and participates in developing new methods for funding energy technology companies and looking for innovative financing models. It is carried out in collaboration with the private and public sectors. Sitra's Cleantech Finland also builds international co-operation networks with funding enterprises and other actors in the EU and accession candidate countries.

INTERNATIONAL COLLABORATION

Given its relatively small size, Finland has by necessity designed its energy R&D platform with an outward focus. As such, international collaboration – in research, funding and other means – is critical to the future growth of Finland's energy industries. Finland has an active network of international collaboration in the area of energy technology R&D. For example, to promote international R&D co-operation, Tekes manages a global network of technology companies, universities and research organisations. Tekes also funds collaborative R&D projects and facilitates researcher mobility. Tekes is actively building partnerships with R&D financiers in Europe, Asia and North America. The Tekes office in Brussels fosters collaboration between the European R&D programmes, the Finnish innovation system and the Tekes technology programmes (see Box 6).

Complementing this activity, the Academy of Finland co-operates with the Research Council of Norway, the Swedish Energy Agency and the Nordic Energy Research Institute to foster Nordic innovative and multidisciplinary basic research. The Academy of Finland is working with key developing countries, including China and Brazil, on bioenergy technology collaboration. VTT actively networks with R&D institutes and industrial partners worldwide to advance new technologies, particularly in the area of bioenergy. Finally, Finland is a member of 21 IEA implementing agreements, particularly those related to energy efficiency and renewable energy.

CRITIQUE

Finland is a leader in energy technology R&D. This is the result of a series of positive government decisions, including stable funding for R&D, strong national and regional organisations (particularly Tekes and VTT) that specialise in key technology areas, active international collaboration and strong private-sector involvement in most aspects of the R&D process. In particular, the country is very good at leveraging its public funds to bring additional private investment – a key feature of much of its energy research funding. Finland also features a unique approach that sets it apart from other countries: it has consistent, systematic support along the full energy R&D chain, including basic research, applied energy R&D, demonstration and assistance in financing, and commercialisation and export of innovative technologies. This approach helps Finland avoid the so-called "valley of death" that other nations experience between demonstration and market penetration of new technologies. Stemming from these attributes, Finland is well-positioned to continue its leadership in some key energy technology areas, including biomass power and biofuels, advanced combustion, distributed energy and nuclear energy.

Box 6

Finland: A Leader in International Collaboration

The EU 7th Research Framework Programme. The extensive EU Research Framework Programme provides opportunities for almost all fields of research. Tekes hosts the Finnish Secretariat for EU R&D, which shares statistics, news and information concerning the prospects offered by EU R&D programmes.

ERA-NET. ERA-NETs are networks of national science and technology funding organisations in Europe. Their co-operation is funded from the EU Research Framework Programme. Tekes participates in roughly 20 ERA-NETs.

EUREKA. EUREKA is a pan-European network for market-oriented and industry-related R&D. It promotes the competitiveness of European companies by creating links and networks of innovation. Tekes is the co-ordinator of EUREKA activities in Finland.

European Co-operation in Scientific and Technical Research (COST). Finland has been highly active in taking advantage of international networking opportunities and participates in two-thirds of the almost 200 current COST activities. Tekes co-ordinates COST activities in Finland.

Innovation Relay Centre (IRC) Finland. Finland is an active member of the international IRC network, which helps small and medium-sized enterprises with transnational technology transfers. This includes technology licensing, subcontracting and co-operation in manufacturing, product development and joint ventures.

Nordic Innovation Centre (NICe). The Nordic Innovation Centre operates under the auspices of the Nordic Council and the Nordic Council of Ministers. Its principal role is to initiate and finance projects and activities that create synergy among key players in the Nordic innovation system.

Association for Technology Implementation in Europe (TAFTIE). TAFTIE is the European association of leading national innovation agencies. Its members share best practices to develop their services and operations. TAFTIE represents the views of its members to European decision makers.

However, continued leadership is not guaranteed, particularly in an age of increased attention – and corresponding international and EU policies – on climate change, energy security, energy efficiency and renewable energy. If Finland is to maintain its leadership in energy technologies in the coming decades, it will have to take additional steps.

Perhaps the most important improvement that could be made is for the government to provide the R&D community with greater guidance on its energy R&D priorities. For good reason, the government leaves the research community much control in setting the research agenda. This prevents excessive government interference and encourages policy stability. Nevertheless, in light of the significant energy challenges that Finland faces, the government should do more to guide the overall energy technology and R&D priorities of its research actors, including Tekes, VTT and the Academy of Finland.

There are several options available to the government as it attempts to develop and share a longer-term energy R&D framework with the research community. One option that has had success in several countries is to conduct a top-down energy road-mapping process that involves stakeholders from industry, academia, non-profit institutions and, importantly, a wide range of government agencies with a hand in energy research. This process could also involve international experts to review and share experiences.

A key question the government should ask during such a strategy-setting exercise is how the country can diversify its energy R&D portfolio so that it maximises near-term results and market attractiveness while also maintaining a focus on Finland's longer-term challenges. This longer-term view will help resolve issues such as the availability of bioenergy feedstocks at appropriate prices, competing land uses and the role of nuclear energy as the country makes the transition to a low-carbon energy sector.

Such a process could be structured so that the government provides clear top-down guidance that signals its long-term research priorities. In addition, this guidance should take a long view, providing a stable framework that is not subject to short-term political interference. One specific benefit of this approach is that it could ensure that Finland's long-term policy goals, and not only the private sector's view on the competitiveness of certain technologies, guide which technologies receive support in the critical deployment stage.

The construction of Olkiluoto 3 has reinvigorated interest in careers in the nuclear industry, including those in operations and research. The government should continue to provide support for training and education of personnel in the nuclear field, as well as basic and applied R&D. Particularly in light of a potential sixth nuclear power plant, maintaining expertise in the field is critical. The same is true for biomass. As this industry is likely to expand even further in the future, the government should ensure that sufficient expertise exists to address Finland's particular challenges and its situation, noting that there is already significant and growing global R&D interest in biomass. In both the nuclear and biomass fields, the government should work with universities and the education field to develop a comprehensive education

and training initiative that develops the personnel needed to realise Finland's long-term energy and environmental policy goals.

RECOMMENDATIONS

The government of Finland should:

- *Provide improved top-down guidance on R&D priorities to Tekes, VTT, the Academy of Finland and other actors.*
- *Establish long-term energy and environment policy goals as a criterion for R&D project funding, rather than allowing R&D investment decisions to depend largely on market competitiveness and export potential.*
- *Develop a national R&D road-map to better focus energy R&D objectives in the short, medium and long term and improve alignment of these activities with policy goals and with Finnish natural resources.*
- *Provide stronger support for next-generation nuclear and bioenergy research to maintain Finland's knowledge base and to ensure that long-term R&D efforts are commensurate with the options to expand these resources in the future.*
- *Complement energy technology policy through a comprehensive education and training initiative, giving guidance and signals to students and young people in order to provide properly educated, skilled and trained manpower to the energy field.*

ORGANISATION OF THE REVIEW

REVIEW TEAM

The 2007 IEA in-depth review of the energy policies of Finland was undertaken by a team of energy policy specialists drawn from IEA member countries, the European Commission, the Nuclear Energy Agency and the IEA Secretariat. The team visited Helsinki and TVO's nuclear power plant site at Olkiluoto from 21 to 25 May 2007 for discussions with energy administration officials, regulators, energy industry groups and non-governmental organisations. This report was drafted on the basis of those meetings and the government's official response to the IEA policy questionnaire, along with other information. The team greatly appreciates the candour and co-operation shown by everyone it met. In particular, the review could not have been possible without the assistance and preparation of Mr. Kim Fyhr from the Ministry of Employment and the Economy.

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Jolanka Fisher managed the review and wrote the report, with the exception of the chapter on energy research and development, which was drafted by Tom Kerr from the IEA's Office of Energy Technology and R&D, the chapter on nuclear power, which was drafted by Torsten Eng from the Nuclear Energy Agency, and the section on coal, which was drafted by Dominika Zahrer. Monica Petit prepared the figures and Bertrand Sadin prepared the maps. Sandra Martin and Viviane Consoli provided editorial assistance.

ORGANISATIONS VISITED

The team held discussions with the following energy and environment stakeholders:

- Energy Department of the Ministry of Employment and the Economy (MEE)
- Energy Market Authority (network regulator)
- Finnish Competition Authority (competition regulator)
- Ministry of Transport and Communications
- Ministry of the Environment
- Fingrid Oyj (transmission system operator)
- Tekes (Finnish Funding Agency for Technology and Innovation)
- Sitra (Finnish Innovation Fund)
- Academy of Finland
- Federation of Finnish Technology Industries
- VTT, Technical Research Centre of Finland
- Finnish Energy Industries
- EK, Confederation of Finnish Industries

- Helsingin Energia
- Greenpeace
- Friends of the Earth
- Finnish Association for Nature Conservation
- Motiva Oy
- Finnish Oil and Gas Federation
- Stora Enso
- TVO (electricity company)
- STUK, Radiation and Nuclear Safety Authority
- POSIVA Oy

REVIEW CRITERIA

The IEA *Shared Goals*, which were adopted by IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The *Shared Goals* are set out in Annex C.

ENERGY BALANCES AND KEY STATISTICAL DATA

Unit: Mtoe

SUPPLY

		1973	1990	2004	2005	2010	2020	2030
TOTAL PRODUCTION		**4.9**	**12.1**	**15.8**	**16.6**	**18.4**	**21.1**	**..**
Coal[1]		–	–	–	–	–	–	..
Peat		0.1	1.8	0.9	2.1	3.3	3.0	..
Oil		–	–	0.1	0.1	–	–	..
Natural gas		–	–	–	–	–	–	..
Comb. renewables & waste[2]		3.9	4.3	7.4	6.9	7.4	7.8	..
Nuclear		–	5.0	5.9	6.1	6.4	9.0	..
Hydro		0.9	0.9	1.3	1.2	1.2	1.2	..
Geothermal		–	–	–	–	–	–	..
Solar/wind/other[3]		–	–	0.2	0.2	0.0	0.1	..
TOTAL NET IMPORTS[4]		**16.6**	**17.7**	**20.7**	**19.0**	**19.4**	**18.9**	**..**
Coal[1]	Exports	0.0	0.0	–	–	..	..	..
	Imports	2.4	4.4	5.5	3.4	4.3	3.9	..
	Net imports	2.4	4.4	5.5	3.4	4.3	3.9	..
Peat	Exports	–	–	0.0	0.0	–	–	..
	Imports	–	–	–	–	–	–	..
	Net imports	–	–	-0.0	-0.0	–	–	..
Oil	Exports	0.2	1.7	5.8	5.2	..	..	..
	Imports	14.0	12.5	17.1	16.4	9.4	9.0	..
	Bunkers	0.1	0.6	0.5	0.5	..	..	..
	Net imports	13.8	10.2	10.9	10.7	9.4	9.0	..
Natural gas	Exports	–	–	–	–	–	–	..
	Imports	–	2.2	3.9	3.6	4.6	5.2	..
	Net imports	–	2.2	3.9	3.6	4.6	5.2	..
Electricity	Exports	0.0	0.0	0.6	0.1	0.4	0.7	..
	Imports	0.4	0.9	1.0	1.5	1.1	1.1	..
	Net imports	0.4	0.9	0.4	1.5	0.7	0.4	..
TOTAL STOCK CHANGES		**-0.1**	**-0.6**	**1.4**	**-0.6**	**–**	**–**	**..**
TOTAL SUPPLY (TPES)		**21.3**	**29.2**	**37.9**	**35.0**	**37.7**	**40.0**	**..**
Coal[1]		2.5	4.1	5.4	3.3	4.3	3.9	..
Peat		0.0	1.2	2.1	1.6	3.3	3.0	..
Oil		13.6	10.3	11.2	10.7	9.4	9.0	..
Natural gas		–	2.2	3.9	3.6	4.6	5.2	..
Comb. renewables & waste[2]		3.9	4.6	7.4	6.8	7.8	8.2	..
Nuclear		–	5.0	5.9	6.1	6.4	9.0	..
Hydro		0.9	0.9	1.3	1.2	1.2	1.2	..
Geothermal		–	–	–	–	–	–	..
Solar/wind/other[3]		–	–	0.2	0.2	0.0	0.1	..
Electricity trade[5]		0.4	0.9	0.4	1.5	0.7	0.4	..
Shares (%)								
Coal		*11.8*	*14.1*	*14.3*	*9.4*	*11.4*	*9.7*	..
Peat		*0.2*	*4.2*	*5.6*	*4.7*	*8.7*	*7.5*	..
Oil		*63.6*	*35.1*	*29.7*	*30.6*	*24.8*	*22.5*	..
Natural gas		–	*7.5*	*10.4*	*10.3*	*12.3*	*12.9*	..
Comb. renewables & waste		*18.5*	*15.6*	*19.4*	*19.6*	*20.6*	*20.5*	..
Nuclear		–	*17.2*	*15.6*	*17.3*	*17.1*	*22.5*	..
Hydro		*4.2*	*3.2*	*3.4*	*3.4*	*3.2*	*3.1*	..
Geothermal		–	–	–	–	–	–	..
Solar/wind/other		–	–	*0.5*	*0.5*	*0.1*	*0.2*	..
Electricity trade		*1.7*	*3.1*	*1.1*	*4.2*	*1.8*	*1.1*	..

0 is negligible, - is nil, .. is not available

Unit: Mtoe

DEMAND

FINAL CONSUMPTION BY SECTOR

	1973	1990	2004	2005	2010	2020	2030
TFC	**19.4**	**22.7**	**26.7**	**25.8**	**29.2**	**30.2**	..
Coal[1]	1.0	1.2	0.7	0.7	0.9	1.0	..
Peat	0.0	0.4	0.3	0.3	0.5	0.5	..
Oil	11.5	9.7	8.9	8.9	9.0	8.7	..
Natural gas	0.0	1.0	0.9	0.9	2.1	2.1	..
Comb. renewables & waste[2]	3.9	3.5	5.0	4.6	5.9	6.2	..
Geothermal	–	–	–	–	–	–	..
Solar/wind/other	–	–	–	–	–	–	..
Electricity	2.3	5.1	7.1	7.0	8.0	8.7	..
Heat	0.6	1.9	3.8	3.6	2.9	3.1	..
Shares (%)							
Coal	*5.3*	*5.1*	*2.7*	*2.9*	*3.0*	*3.2*	..
Peat	*0.1*	*1.8*	*1.0*	*1.0*	*1.8*	*1.6*	..
Oil	*59.2*	*42.6*	*33.5*	*34.3*	*31.0*	*28.9*	..
Natural gas	*0.1*	*4.3*	*3.2*	*3.3*	*7.1*	*6.8*	..
Comb. renewables & waste	*20.3*	*15.5*	*18.7*	*17.6*	*20.2*	*20.4*	..
Geothermal	–	–	–	–	–	–	..
Solar/wind/other	–	–	–	–	–	–	..
Electricity	*11.9*	*22.3*	*26.8*	*26.9*	*27.2*	*28.8*	..
Heat	*3.1*	*8.4*	*14.1*	*13.9*	*9.8*	*10.2*	..
TOTAL INDUSTRY[6]	**7.6**	**10.5**	**13.3**	**12.5**	**15.7**	**16.6**	..
Coal[1]	0.9	1.2	0.7	0.7	0.9	1.0	..
Peat	0.0	0.4	0.2	0.2	0.5	0.5	..
Oil	5.0	2.6	2.4	2.4	2.8	2.8	..
Natural gas	0.0	0.9	0.8	0.8	2.0	2.0	..
Comb. renewables & waste[2]	–	2.5	3.8	3.4	4.7	5.0	..
Geothermal	–	–	–	–	–	–	..
Solar/wind/other	–	–	–	–	–	–	..
Electricity	1.6	2.8	4.0	3.7	4.6	5.1	..
Heat	0.1	0.2	1.4	1.3	0.3	0.3	..
Shares (%)							
Coal	*12.1*	*11.0*	*5.4*	*5.9*	*5.5*	*5.9*	..
Peat	*0.2*	*3.6*	*1.8*	*1.9*	*3.2*	*2.8*	..
Oil	*66.2*	*24.7*	*18.2*	*19.1*	*18.1*	*16.6*	..
Natural gas	*0.1*	*9.0*	*5.7*	*6.1*	*12.5*	*11.9*	..
Comb. renewables & waste	–	*23.4*	*28.6*	*27.1*	*29.9*	*29.9*	..
Geothermal	–	–	–	–	–	–	..
Solar/wind/other	–	–	–	–	–	–	..
Electricity	*20.4*	*26.6*	*29.7*	*29.6*	*29.0*	*31.0*	..
Heat	*1.0*	*1.7*	*10.6*	*10.3*	*1.8*	*1.9*	..
TRANSPORT	**2.6**	**4.4**	**4.9**	**4.9**	**4.5**	**4.4**	..
TOTAL OTHER SECTORS[7]	**9.3**	**7.9**	**8.4**	**8.4**	**9.0**	**9.2**	..
Coal[1]	0.1	0.0	0.0	0.0	–	–	..
Peat	0.0	0.0	0.0	0.0	0.0	0.0	..
Oil	3.9	2.7	1.7	1.6	1.8	1.7	..
Natural gas	0.0	0.0	0.1	0.1	0.1	0.1	..
Comb. renewables & waste[2]	3.9	1.1	1.2	1.2	1.2	1.2	..
Geothermal	–	–	–	–	–	–	..
Solar/wind/other	–	–	–	–	–	–	..
Electricity	0.8	2.2	3.1	3.2	3.3	3.5	..
Heat	0.5	1.7	2.4	2.3	2.6	2.8	..
Shares (%)							
Coal	*1.1*	*0.1*	–	–	–	–	..
Peat	*0.1*	*0.2*	*0.3*	*0.3*	*0.2*	*0.2*	..
Oil	*42.3*	*35.0*	*19.9*	*19.2*	*20.3*	*18.0*	..
Natural gas	–	*0.5*	*0.9*	*0.9*	*0.7*	*0.6*	..
Comb. renewables & waste	*42.6*	*13.6*	*13.8*	*13.8*	*13.2*	*13.0*	..
Geothermal	–	–	–	–	–	–	..
Solar/wind/other	–	–	–	–	–	–	..
Electricity	*8.2*	*28.5*	*37.1*	*38.1*	*37.0*	*38.1*	..
Heat	*5.7*	*22.1*	*27.9*	*27.6*	*28.7*	*30.0*	..

Unit: Mtoe

DEMAND

ENERGY TRANSFORMATION AND LOSSES

	1973	1990	2004	2005	2010	2020	2030
ELECTRICITY GENERATION[8]							
INPUT (Mtoe)	**3.5**	**11.9**	**19.0**	**15.9**	**18.6**	**21.2**	**..**
OUTPUT (Mtoe)	**2.2**	**4.7**	**7.4**	**6.1**	**7.5**	**8.6**	**..**
(TWh gross)	26.1	54.4	85.8	70.6	87.6	99.7	..
Output Shares (%)							
Coal	*18.7*	*18.5*	*20.0*	*10.2*	*15.6*	*11.4*	..
Peat	*9.4*	*14.6*	*7.6*	*6.4*	*10.3*	*8.2*	..
Oil	*31.6*	*3.1*	*0.7*	*0.7*	*0.9*	*0.6*	..
Natural gas	*–*	*8.6*	*14.9*	*15.9*	*15.1*	*16.4*	..
Comb. renewables & waste	*–*	*–*	*12.4*	*13.7*	*13.6*	*13.1*	..
Nuclear	*–*	*35.3*	*26.5*	*33.0*	*28.2*	*34.7*	..
Hydro	*40.3*	*20.0*	*17.6*	*19.5*	*15.8*	*14.4*	..
Geothermal	*–*	*–*	*–*	*–*	*–*	*–*	..
Solar/wind/other	*–*	*0.1*	*0.2*	*0.5*	*1.1*	*..*	
TOTAL LOSSES	**2.0**	**7.2**	**10.4**	**8.6**	**8.5**	**9.8**	**..**
of which:							
Electricity and heat generation[9]	0.6	5.1	7.6	6.1	8.0	9.3	..
Other transformation	0.5	0.6	1.0	0.8	..	..	..
Own use and losses[10]	0.9	1.4	1.8	1.7	0.5	0.6	..
Statistical differences	**–0.07**	**–0.70**	**0.79**	**0.53**	**–**	**–**	**..**

INDICATORS

	1973	1990	2004	2005	2010	2020	2030
GDP (billion 2000 USD)	61.03	100.29	133.93	137.84	159.76	196.66	..
Population (millions)	4.67	4.99	5.23	5.25	5.27	5.32	..
TPES/GDP[11]	0.35	0.29	0.28	0.25	0.24	0.20	..
Energy production/TPES	0.23	0.41	0.42	0.47	0.49	0.53	..
Per capita TPES[12]	4.57	5.85	7.24	6.67	7.16	7.53	..
Oil supply/GDP[11]	0.22	0.10	0.08	0.08	0.06	0.05	..
TFC/GDP[11]	0.32	0.23	0.20	0.19	0.18	0.15	..
Per capita TFC[12]	4.16	4.56	5.11	4.93	5.55	5.68	..
Energy-related CO_2 emissions ($MtCO_2$)[13]	48.4	55.0	67.3	55.4	69.4	66.9	..
CO_2 emissions from bunkers ($MtCO_2$)	0.5	2.8	2.9	2.9	1.5	1.8	..

GROWTH RATES (% per year)

	73–79	79–90	90–04	04–05	05–10	10–20	20–30
TPES	2.3	1.6	1.9	–7.6	1.5	0.6	..
Coal	7.4	0.6	2.0	–39.0	5.5	–1.0	..
Peat	48.1	10.6	4.0	–22.4	14.9	–0.9	..
Oil	–0.5	–2.3	0.7	–4.7	–2.7	–0.4	..
Natural gas	–	9.4	4.3	–8.9	5.1	1.1	..
Comb. renewables & waste	–2.4	2.7	3.5	–6.9	2.6	0.5	..
Nuclear	–	10.0	1.2	2.4	1.2	3.4	..
Hydro	0.6	–0.0	2.4	–8.6	0.1	0.4	..
Geothermal	–	–	–	–	–	–	..
Solar/wind/other	–	–	–	–3.0	–16.2	9.4	..
TFC	0.4	1.2	1.2	–3.2	2.5	0.3	..
Electricity consumption	4.7	4.7	2.5	–2.6	2.7	0.9	..
Energy production	4.7	5.9	1.9	5.0	2.1	1.4	..
Net oil imports	1.1	–3.3	0.4	–1.7	–2.6	–0.4	..
GDP	2.5	3.2	2.1	2.9	3.0	2.1	..
Growth in the TPES/GDP ratio	–0.2	–1.5	–0.2	–10.3	–1.4	–1.5	..
Growth in the TFC/GDP ratio	–2.1	–1.9	–0.9	–5.9	–0.5	–1.7	..

Please note: Rounding may cause totals to differ from the sum of the elements.

FOOTNOTES TO ENERGY BALANCES AND KEY STATISTICAL DATA

1. Coal excludes peat, which is shown separately.
2. Combustible renewables and waste comprises solid biomass, liquid biomass, biogas, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
3. Other includes ambient heat used in heat pumps.
4. Total net imports include combustible renewables and waste and trade of electricity.
5. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
6. Industry includes non-energy use.
7. Other sectors include residential, commercial, public services, agriculture, fishing and other non-specified sectors.
8. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
9. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and 100% for hydro and solar photovoltaics.
10. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
11. Toe per thousand US dollars at 2000 prices and exchange rates.
12. Toe per person.
13. "Energy-related CO_2 emissions" have been estimated using the IPCC Tier I Sectoral Approach. In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals. Projected emissions for oil and gas are derived by calculating the ratio of emissions to energy use for 2005 and applying this factor to forecast energy supply. Future coal emissions are based on product-specific supply projections and are calculated using the IPCC/OECD emission factors and methodology.

INTERNATIONAL ENERGY AGENCY "SHARED GOALS"

The 27 member countries* of the International Energy Agency (IEA) seek to create the conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants.

In order to secure their objectives they therefore aim to create a policy framework consistent with the following goals:

1. **Diversity, efficiency and flexibility within the energy sector** are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydropower, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies**. In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. **The environmentally sustainable provision and use of energy** is central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should where practicable have regard to the "polluter pays principle".

4. **More environmentally acceptable energy sources** need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA members wish to retain and improve

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, the Slovak Republic (since November 2007), Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. **Improved energy efficiency** can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. **Undistorted energy prices** enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. **Free and open trade** and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. **Co-operation among all energy market participants** helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.)

GLOSSARY AND LIST OF ABBREVIATIONS

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention in each chapter, this glossary provides a quick and central reference for many of the abbreviations used.

AAU	assigned amount unit (under the Kyoto Protocol)
bcm	billion cubic metres
b/d	barrels per day
BWR	boiling water reactor
CCGT	combined-cycle gas turbine
CDM	clean development mechanism (a flexibility mechanism under the Kyoto Protocol)
CER	certified emissions reduction (under the clean development mechanism of the Kyoto Protocol)
CHP	combined production of heat and power; sometimes, when referring to industrial CHP, the term "co-generation" is used
CO_2	carbon dioxide
EMA	Energy Market Authority
ERU	emissions reduction unit (under joint implementation of the Kyoto Protocol)
ESCO	energy service company
EU	European Union
EU-ETS	European Union Emissions Trading Scheme
EUR	Euro (€); EUR 1 = USD 1.25 (average exchange rate in 2006)
G8	Group of Eight, an international forum for the governments of Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States

g	gramme
GCV	gross calorific value
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt, or 1 watt × 10^9
GWh	gigawatt-hour = 1 gigawatt × 1 hour
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ITER	International Thermonuclear Experimental Reactor
JI	joint implementation (a flexibility mechanism under the Kyoto Protocol)
kb/d	thousand barrels per day
kcal	kilocalorie, or 1 calorie × 10^3, equivalent to 10^{-7} toe
kg	kilogramme
km	kilometre, or 1 metre × 10^3
ktoe	thousand tonnes of oil equivalent; see "toe"
kV	kilovolt
kWh	kilowatt-hour = 1 kilowatt × 1 hour = 1 watt × 10^3 × one hour
L	litre
LNG	liquefied natural gas
m^2	square metre
m^3	cubic metre
mcm	million cubic metres
MEE	Ministry of Employment and the Economy (includes the former Ministry of Trade and Industry)
Mt	million tonnes
$MtCO^2$	million tonnes of carbon dioxide
$MtCO^2$-eq	million tonnes of carbon dioxide equivalent

MTI	Ministry of Trade and Industry (now merged into the Ministry of Employment and the Economy)
Mtoe	million tonnes of oil equivalent; see "toe"
MW	megawatt, or 1 watt × 10^6
MW_e	megawatt of electric capacity
MWh	megawatt-hour = 1 megawatt × 1 hour
MW_{th}	megawatt of thermal capacity
OCGT	open-cycle gas turbine
OECD	Organisation for Economic Co-operation and Development
PVO	Pohjolan Voima (electricity and heat company)
PWR	pressurised water reactor
R&D	research and development, especially in energy technology; may include the demonstration and dissemination phases as well
STUK	Radiation and Nuclear Safety Authority
Tekes	Finnish Funding Agency for Technology and Innovation
TFC	total final consumption of energy
toe	tonne of oil equivalent, defined as 10^7 kcal
TPES	total primary energy supply
TUKES	Safety Technology Authority
TVO	Teollisuuden Voima (electricity company)
TWh	terawatt-hour = 1 terawatt × 1 hour = 1 watt × 10^{12} × 1 hour
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollar ($); USD 1 = EUR 0.80 (average exchange rate in 2006)
VAT	value-added tax
VTT	Technical Research Centre of Finland

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