INTERNATIONAL ENERGY AGENCY



## Energy Policies of IEA Countries

# **FINLAND** 2003 Review



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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 cooperation among twenty-six\* of the OECD's 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 nonmember 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 assist in the integration of environmental and energy policies.

\* IEA member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.

#### ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original member countries of the OECD are Austria. Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995). Hungary (7th May 1996). Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

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## SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

#### **SUMMARY**

Finnish energy policy is characterised by three commendable traits. One, Finland employs a holistic approach to energy. Its energy policy strives to simultaneously pursue the three E's – Energy security, Economic development and Environmental sustainability. This approach is apparent in the effective communication on energy policy issues between the various ministries and energy programmes which pursue numerous policy goals in tandem and act in concert rather than in conflict with one another.

Two, Finnish energy policy successfully employs international trade to lower energy costs and enhance energy security. Finland's lack of substantial domestic energy resources requires significant imports. Efforts to import fuels and electricity from a variety of countries provide Finland with a diverse energy supply, which lowers costs and enhances energy security. As part of the Nordic Power Market (Nordpool), Finland has successfully integrated its electricity market with those of the Scandinavian countries.

Three, Finland applies a light-handed approach to energy regulation. Its electricity sector is one of the least regulated in the world, with companies free to build power plants as they wish and all customers free to choose their supplier. Most of the regulation is done *ex post*, meaning that companies that own and operate assets still considered to fall under regulatory review, such as electricity networks and district heating suppliers, have significant leeway to set their own tariff structures. While this approach has been successful overall for Finland, this in-depth review identifies a few selected areas where regulatory authority could be expanded.

The most important energy development since the last in-depth review four years ago is the development of a new nuclear power plant, scheduled to come on line in 2009. While Finland already has two such facilities – providing 30% of the country's power generation with four reactors – the new plant would be the first nuclear facility built in a liberalised electricity sector. In May 2002, the Parliament ratified the government's earlier decision-in-principle in favour of the plant. While this decision implied neither state guarantees for the plant nor a specific endorsement of the project, it did allow the development of the project to proceed.

This new nuclear facility could help Finland meet its need for new generating capacity without producing new greenhouse gases (GHG). However, nuclear facilities worldwide have in the past faced cost overruns and delays, so the

government is encouraged to closely monitor the progress of the plant and be prepared to provide alternatives for both electricity capacity and GHG mitigation should delays or other obstacles arise.

Under the Kyoto Protocol, Finland has agreed to keep its GHG emissions at 1990 levels during the 2008-2012 target period. Initial assessments indicate that emissions were 9% above 1990 levels in 2002. This anomalously high figure could be the consequence of low availability of hydroelectricity during the year. Nevertheless, measures will have to be implemented to address this issue given that business-as-usual projections by the government indicate further increases in GHG, reaching 15% above 1990 levels during the first target window.

In June 2001, the Parliament passed the National Climate Strategy (NCS) to curb GHG emissions. The NCS focuses on domestic measures as the best way to reduce Finland's GHG emissions, and includes an impressive array of programmes in all emission-producing sectors. While domestic emissions cutting measures do present a number of advantages, Finland should also rigorously explore the use of international mechanisms, especially emissions trading. This is particularly true given the high variability of Finland's emissions owing to climatic reasons, such as hydro availability and heating needs in the winter. If emissions are higher than predicted during the Kyoto window, it will be too late to employ domestic measures, which take years to implement. Consequently, international mechanisms will be essential and their optimal utilisation should be implemented in a timely manner. Large emissions cuts are expected to come from the proposed nuclear plant coming on line in 2009. However, if the plant is delayed. Finland will need to rapidly cut substantial emissions, and international mechanisms are well suited for this purpose. International mechanisms may also provide Finland with a lower-cost alternative to cutting emissions than the exclusive use of domestic measures.

Energy security is particularly important for Finland. On the supply side, the country lacks substantial domestic fossil fuels and its geographical position limits the amount of energy interconnections it can feasibly construct. While imported fuels do not necessarily imply greater risk than domestic fuels, high import levels do require monitoring. On the demand side, the country's cold climate and the significance of its energy-intensive industry make the reliable supply of energy particularly important.

Finland has responded well to its energy security challenges. It has emergency stocks of imported fuels corresponding to five months' average consumption (or import) based on the Security of Supply Act, which is far beyond the IEA stock obligation in terms of volume and coverage. Finland has a diverse mix of primary energy supplies, with five different fuels contributing at least 10% to the country's total primary energy supply (TPES). Finland relies on market mechanisms to ensure that sufficient electricity capacity is available. The

electricity market will be tested in the coming years as new capacity will be required. The government should monitor this situation and respond if the market is incapable of adding the needed plant. The extensive use of fuelswitching for natural gas also enhances energy security. While all natural gas is imported from just one source (Russia), extensive fuel-switching capabilities and the compulsory oil stocks to replace natural gas in the event of disruption help to mitigate this exposure.

Renewable resources give Finland substantial emission-free domestic energy sources. Biomass and hydroelectricity account for 20% and 3% respectively of the country's TPES. The government is using a number of support programmes with the objective to increase the use of renewable energy by 30% by 2010. While this can benefit Finland, the support schemes could be rendered more effective, and perhaps less costly, through a more market-based approach. This is particularly the case for the investment subsidies the government spends to encourage specific types of renewable energy.

## RECOMMENDATIONS

The government of Finland should:

#### Energy Market and Energy Policy

- Continue the country's holistic approach to energy policy, including the strategy of pursuing numerous goals in tandem and with successful co-ordination between relevant ministries.
- Continue to expand the international approach to reaching energy policy goals, particularly regarding interconnections and the most cost-effective means of meeting climate change obligations.
- Enhance the energy regulator's role through expansion of staff and budget, especially for electricity transmission and distribution and for district heating, in order to further improve the efficiencies of these sectors.
- Continue to augment the country's energy security of supply through emergency preparedness, market mechanisms in the electricity sector, fuel diversity and fuel-switching capabilities.

#### Energy and the Environment

• Proceed with the implementation of the energy efficiency and renewable energy elements of the NCS in order to effect the needed changes by the time of the first Kyoto commitment window.

- ▶ Continue to undertake energy supply-demand and CO₂ emissions projections, evaluate the progress of the NCS and update it as required to achieve the Kyoto target in the most cost-effective manner.
- Closely follow the development of the fifth nuclear power reactor and consider alternative emissions reduction plans in the event that the planned nuclear facility does not come on line in the expected time frame.
- Review the package of measures on the supplementary role that emissions trading can play, particularly regarding potential overlaps with domestic measures.
- Determine a framework for allocation of emissions allowances in the relevant sectors as soon as possible.
- Assess the advantages, particularly in terms of cost-effectiveness, of the application of joint implementation and clean development mechanisms.

#### **Energy Efficiency**

- Study the issue of cross-subsidies between district heating and electricity operations, and evaluate possibilities to improve transparency and competition in the district heating sector, starting with large heating networks. Consider the possibility of extending Energy Market Authority jurisdiction over the district heating sector.
- Expand the analysis of the energy efficiency aspects of heating choices in new residences.
- Examine the legal, economic and technical possibilities for developing heat metering in individual apartments that are currently billed according to static indicators on consumption, often with a flat fee.
- Review the use of voluntary agreements for industry in light of the European Union directive on emissions trading. Consider more stringent energy conservation targets in the agreements.
- Consider introducing more sophisticated economic signals that would favour a more fuel-efficient private car fleet, for example through an annual circulation tax or taxes on acquisition.
- Continue to encourage combined heat and power (CHP) production and new investment, especially for plants fuelled with renewable energy.

#### Renewable Energy

• Evaluate the existing support scheme for renewables with the aim of developing a market-based system that will achieve emissions reductions at a minimal cost and give incentives to reduce production costs from renewables.

- Take measures to simplify and accelerate licensing and appeal procedures of wind and small hydropower plants.
- Explore measures to increase the economic supply of biomass.

#### Fossil Fuels and Peat

- Continue to value peat for its energy security advantages, while taking into account its costs and environmental implications.
- Continue the policy of non-interference in the oil markets, combined with effective anti-trust oversight.
- Explore the use of different methodologies to establish natural gas tariffs.
- Examine opportunities to expand the unregulated secondary gas market as a means of gaining more experience with competition in the sector and promoting, where possible, greater efficiency in gas use by customers.
- Continue to examine additional international gas connections, working with multi-country partnerships to find and develop economically feasible options that can increase security of supply and possibilities for competition.

#### Electricity

- Make greater efforts to harmonise rules in the Nordic electricity market, particularly common approaches to enhancing security of supply and market oversight.
- In order to ensure more efficient development of transmission infrastructure, adopt a common Nordic approach to mechanisms for financing transmission investment.
- Make greater use of ex ante regulation, particularly to encourage more efficient pricing of transmission and the disposition of transmission congestion rents.
- Proceed with the legal separation of distribution from retailing. Evaluate the minimum size of companies to be separated.
- Examine further measures to increase customer choice, including supplier of last resort policies.

#### Nuclear Power

- Ensure that the licensing process for the new plant is completed without unnecessary delay within the current regulatory framework.
- Pursue active regulatory support for the implementation of the high-level waste repository.

#### **Energy Research and Development**

- Develop an indicator or set of indicators that manages to better assess the effectiveness of government-funded energy research and development (R&D) efforts.
- Monitor and support the industry R&D effort to ensure that the existing and future nuclear power plants continue to improve their technical and safety performances and that radioactive waste is managed and disposed of safely.

## **ORGANISATION OF THE REVIEW**

#### **REVIEW TEAM**

The 2003 IEA in-depth review of the energy policies of Finland was undertaken by a team of energy specialists drawn from IEA member countries and the IEA Secretariat. The team visited Finland from 16 to 21 March 2003 to meet with government officials, energy suppliers and energy consumers. This report was drafted on the basis of those meetings and the government's official response to the IEA's 2002 policy questionnaire. The team greatly appreciates the openness and co-operation shown by everyone it met.

The members of the team were:

#### Hugo Brouwer (team leader)

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Jonathan Coony managed the review and drafted the report. Monica Petit and Bertrand Sadin prepared the figures, and Sandra Martin edited the text.

#### **ORGANISATIONS VISITED**

The team held discussions with the following:

- Ministry of Trade and Industry
- Ministry of the Environment
- Ministry of Transport and Communications

- National Consumer Administration
- Finnish Competition Authority
- Energy Market Authority
- Radiation and Nuclear Safety Authority (STUK)
- National Technology Agency (Tekes)
- Motiva
- Fingrid (Transmission System Operator)
- Finnish Electricity Association (SENER)
- Finnish District Heating Association (FDHA)
- Finnish Energy Industries Federation (Finergy)
- Confederation of Finnish Industry and Employers
- Finnish Oil and Gas Federation
- Helsinki Energy
- Fortum
- Gasum
- Teollisuuden Voima (TVO)
- Wartsila Corporation
- Central Union of Agricultural Producers and Forest Owners
- Finnish Association for Nature Conservation

The assistance and co-operation of all participants in the review are greatly appreciated.

## **REVIEW CRITERIA**

The IEA *Shared Goals*, which were adopted by the 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 B.

## COUNTRY OVERVIEW

Along with its Nordic neighbours, Norway and Sweden, Finland is one of the northernmost countries in Europe. Almost the entire national territory is situated between 60 and 70 degrees northern latitude. Approximately one-third of all people living north of the  $60^{th}$  parallel are Finns. February mean average temperatures in the north are approximately  $-13^{\circ}$ C and in the south  $-5^{\circ}$ C, while July temperatures in the north are about  $14^{\circ}$ C and in the south  $17^{\circ}$ C. The population-weighted average number of heating degree days for Finland is approximately 5 000, significantly above the 4 000 heating degree days seen in Norway and Sweden.

Finland has a population of 5.2 million of which approximately two-thirds live in urban areas. The population is heavily concentrated along the southern coast. Finland has the lowest population density among European Union (EU) countries with 15 inhabitants per square kilometre. More than 75% of the country is covered by boreal coniferous forests and 10% by lakes.

During the last half of the twentieth century, Finland transformed itself from a predominantly farm and forest economy to a diversified modern industrial economy. It is currently one of the leaders in information technology products. Finland joined the EU in 1995 and was the only Nordic country to adopt the euro at its inception in January 1999.

A number of Finland's industries, including basic metals, pulp and paper, chemicals and non-metallic minerals, are both energy-intensive and subject to international competition. These industries account for 40% of the country's industrial gross domestic product (GDP) and over 80% of industrial energy use. The majority of plants in these industries have electricity and/or heat generating stations on site, with the pulp and paper industry using waste products for significant portions of its fuel.

The Finnish economy performed well in the late 1990s, averaging real GDP growth of 5.2% in the three years from 1998 to 2000. The economic pace has since slowed down with GDP growth falling to 1.2% in 2001 and 2.2% in 2002. Growth is forecast at 1.2% in 2003 and 2.4% in 2004.

## **ENERGY MARKET**

In 2001, Finland's total primary energy supply (TPES) was 33.8 million tonnes of oil equivalent (Mtoe). From 1997 to 2000, the average TPES growth rate

was 0.6% per year. Although this figure was comparable to the 0.7% average annual TPES rate for IEA European countries from 1996 to 2000, it represented approximately half of Finland's average annual TPES from 1973 to 2000.

Finland's primary fuel supply is diverse. The largest contributor is oil, which in 2001 accounted for 28% of TPES. Four other fuel sources contribute at least 10% each, including biomass (20%), nuclear power (18%), coal (12%) and natural gas (11%). The fuel mix is projected to become further diversified as oil's share of TPES falls to 24% by 2010 with gains made by nuclear, coal and natural gas. Wind power is the fastest growing energy source, having increased its output by 200% from 1998 to 2001. Nevertheless, its contribution remains small, accounting for only 0.02% of TPES in 2000. By 2010, it is expected to represent 0.08% of TPES and by 2020, 0.14%.



Sources: Energy Balances of OECD Countries, IEA/OECD Paris, 2003 and country submission.

The majority of Finland's TPES is imported. The largest source of domestic fuel is biomass, which accounts for 20% of TPES. Peat accounts for 6% and hydro 3%. In 2001, approximately 54% of TPES was imported. In addition, all of the country's uranium, which represents 18% of TPES, was imported.

## ENERGY DEMAND

In 2001, total final consumption of energy (TFC) was 25.2 Mtoe. This represents an average annual increase of 1.5% from 1997 to 2001. The industrial sector is by far the largest energy user in Finland. In 2001, it accounted for 47% of TFC, compared with 31% for IEA European countries as a whole. Industry's share of TFC has grown steadily and is expected to rise to 52% by 2010. The residential sector is the second-largest energy user, representing 20% of TFC, followed by road transport with 15%. TFC in both of these sectors is projected to grow in absolute terms in the coming decade, but is expected to decline as a share of the national total as industry consumes more energy.



## **GENERAL ENERGY POLICY**

Finland's energy policy focuses on the three E's – Energy security, Economic development and Environmental sustainability. The following energy policy objectives are based on the Energy Strategy that was elaborated and adopted in 1997:

• Development of the structure of energy production towards reduced emissions of carbon compounds.

- 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.

These goals were reconfirmed in the 2001 National Climate Strategy (NCS).

Energy production, generation, transmission and use are subject to light-handed regulation. In general, energy prices are determined solely by market forces. In areas where natural monopolies or *de facto* natural monopolies exist, regulation tends to be *ex post*, with a limited number of cases coming before the regulatory bodies.

Finland's energy policy has a strong international component. After the deregulation of the electricity market, co-operation has considerably increased between the Nordic regulatory bodies and other bodies responsible for the security of supplies. Finland's membership in the European Union (EU) also influences its energy policy through both the directives on the internal market and frameworks and the guidelines on national policies promoting indigenous fuels, energy efficiency or R&D.

## **ENERGY POLICY INSTITUTIONS**

## MINISTRY OF TRADE AND INDUSTRY

The Ministry of Trade and Industry (MTI) has the overall co-ordination and planning role for Finnish energy policy. Energy policy is the responsibility of MTI's Energy Department, which consists of the Climate Change and Energy Strategy Secretariat, the Energy Market and Environment Division, the Renewables and Energy Efficiency Division and the Nuclear Energy Division. MTI also has jurisdiction over all energy policy areas for which no other suitable agencies exist. MTI works closely with other ministries, including the Ministries of Finance (taxation and subsidies), Environment ( $CO_2$  and other environmental issues), Transport and Communications (transportation), Agriculture and Forestry (biofuels and sinks) and Foreign Affairs (international co-operation). MTI, in consultation with other relevant ministries, is leading the development and implementation of the NCS.

MTI seeks to promote energy efficiency and competition in the energy sector. It produces information, performs analyses and provides services both to

decision-makers and producers of energy. It seeks to create conditions that ensure an adequately diverse energy supply by supporting progress in the energy market, the efficient use of energy and energy conservation.

#### NATIONAL EMERGENCY SUPPLY AGENCY

The National Emergency Supply Agency (NESA) operates under MTI and is responsible for ensuring that Finland complies with its emergency reserve requirements. Monitoring of this compliance is the responsibility of NESA's Department of Energy Supply. Finland's reserve requirements are more extensive than would be necessary under the EU legislation and the IEA International Energy Program (IEP), corresponding to five months' internal consumption and, in addition to crude oil, also include coal, uranium and oil products.

#### ENERGY MARKET AUTHORITY

The Energy Market Authority (EMA) is an expert body subordinate to MTI. It acts as the Finnish energy regulator. It started as the Electricity Market Authority on 1 June 1995, at the same time as the Electricity Market Act took effect, opening the electricity market to competition. It became the Energy Market Authority on 1 August 2000, at the same time as the Natural Gas Market Act took effect. EMA currently employs 16 staff.

EMA aims to promote healthy and efficient competition in the electricity and natural gas markets and to secure reasonable and equitable service principles in electricity and gas grid operations. EMA's principal task is to supervise the pricing of transmission, distribution and other grid services. It uses an *ex post* case-by-case regulatory approach to ensure that the pricing of grid services by distribution and transmission grid operators is reasonable and non-discriminatory. Cases are brought up either through complaints, or on the initiative of EMA itself. EMA also grants grid licences to organisations and utilities engaged in grid operations, and building permits for constructing power lines of 110 kV and higher voltages. In the future, EMA will also be responsible for  $CO_2$  emission allowance trading registers and will grant  $CO_2$  emissions licences.

#### FINNISH COMPETITION AUTHORITY

The Finnish Competition Authority, formerly the Office of Free Competition, operates under MTI with the objective to protect sound and effective economic competition and to increase economic efficiency. The Competition Authority investigates and decides whether utilities are providing their products and services at reasonable terms and prices. Since Finland employs *ex post* regulation, such an investigation is only launched in response to a specific customer complaint.

## MOTIVA OY

Motiva Oy, formerly the Energy Information Centre for Energy Efficiency and Renewable Energy Sources, is an impartial and state-owned joint stock company with 23 staff and an annual turnover of  $\notin$ 4 million. Its principal objective is to implement government policies on energy conservation and the promotion of renewable energy sources. Motiva disseminates information through fairs, exhibitions, seminars, publications, the *Motiva Xpress* newsletter and the National Energy Awareness Week; it develops and markets energy audits as well as other energy management procedures and promotes energy-efficient technologies. Motiva receives most of its funding from MTI.

## THE NATIONAL TECHNOLOGY AGENCY

The National Technology Agency (Tekes) finances research and development (R&D) projects for Finnish companies and universities. The funds are awarded from the state budget via MTI. Tekes also co-ordinates and finances Finnish participation in international technology initiatives. The technology programmes promote development in specific sectors of technology or industry, including energy, and pass the results of the research work to businesses in an efficient manner. Currently, there are eleven on-going R&D programmes in energy and environment technology.

Technology programmes are planned in co-operation with companies, research institutes and Tekes. The board of Tekes makes all decisions to launch research programmes. Each technology programme has a steering group, a co-ordinator and a desk person at Tekes. The duration of the programmes range from three to five years and their size from some millions to several tens of millions of euros. Tekes usually finances about half of the programme costs, while the balance is provided by the participating companies.

## TECHNICAL RESEARCH CENTRE OF FINLAND

The Technical Research Centre of Finland (VTT) has an energy research branch of about 340 staff. In the energy field, 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. VTT acts as a technical research organisation with energy R&D policy being set and directed by Tekes. VTT is a government organisation operating under the auspices of MTI and other relevant ministries, depending on the technology being researched.

## RADIATION AND NUCLEAR SAFETY AUTHORITY

The Radiation and Nuclear Safety Authority (STUK) sets the regulations for the use of radiation and nuclear energy and ensures that they are followed. STUK is also an expert institute that carries out research on radiation and its effects, determines risks caused by radiation and monitors the radiation safety of the Finnish environment.

## SECURITY OF ENERGY SUPPLY

## OIL AND OIL PRODUCTS

Finland has no domestic production of oil, importing all its crude oil from the international market. The 1992 Security of Supply Act is the legal basis for ensuring supplies of various basic materials, including oil in the case of emergency situations. According to the decision of the Council of State in May 2002, the target for stocks of imported fuels corresponds to five months' average consumption, which is significantly above the 90 days mandated by the IEA. The National Emergency Supply Agency (NESA), a subordinate agency to MTI, is responsible for the development and maintenance of security of supply.

#### NATURAL GAS

In 2001, natural gas accounted for 11% of Finland's TPES and is expected to grow slightly to 12% by 2010. All gas is currently imported from Russia. There have been numerous plans and projects to connect Finland with other gas exporting and consuming countries but none has been pursued. While there has been significant interest in international pipeline projects, further political and financial co-ordination will be required for their implementation. Since 1974, when imports began, the only supply disruption of consequence occurred in 1991 when Russian pipeline damage suspended delivery to Finland for 36 hours. Larger customers switched to on-site oil products reserves and smaller customers used the gas already in the pipeline. Since that time, the Russians have installed a parallel backup line running from St. Petersburg to the Finnish border.

Approximately 90% of gas use is backed up by on-site oil products and the dual-fuel firing capacity of the boilers. In the event of a supply disruption, the remaining 10% of gas demand could be served via a 350 MW propane-air mixing station in Porvoo, which could introduce this "synthetic gas" into the transmission pipeline. This station has never been used to supply customers. Finland has no gas storage owing to a lack of depleted gas fields and suitable geology. However, the pipeline itself can store approximately one-half day's worth of demand.

## PEAT, COAL AND BIOMASS

Peat, coal and biomass provide secure energy sources for Finland. Peat is a domestically harvested product that provided Finland with 5.7% of its TPES

and 8.3% of its electricity in 2001. While Finland has no domestic coal production, its continued import – primarily from Russia and Poland – is considered a secure supply source. In addition, the Security of Supply Act stipulates that suppliers must stock a five-month supply of coal. In 2000, coal provided 11% of the country's TPES, and over 13% of its electricity generation. In 2001, biomass, which is domestically harvested, provided 20% of Finland's TPES and accounted for 12% of electricity production. It is used in both industrial processes and district heating schemes.

#### ELECTRICITY

An analysis of Finland's security of electricity supply must consider its interconnections with Russia and with the rest of the Nordic market. The major interconnection with Russia provides a significant amount of Finland's electricity. The supply of this electricity to date has been quite reliable.

The events of the winter 2002/2003 demonstrated the Nordic electricity market's ability to withstand the challenge of a winter with very low hydropower capability. Market mechanisms worked well, attracting imports of electricity and encouraging reduction in demand elsewhere in the Nordic market region.

The Nordic countries' increasing electricity demand will augment their reliance on electricity imports, even in normal years. Nevertheless, the Association of Nordic Electricity Companies' (Nordel) energy balance analysis for the region concludes that the entire region will still be able to cope with a single dry year out to 2006/2007 without serious difficulties through its reliance on imports. However, a very dry year may cause difficulties that market mechanisms may not be able to accommodate (see Chapter 8 on electricity).

#### **ENERGY TAXATION**

From September 1998 through 2002, the structure and level of energy taxation remained unchanged. However, the government stated in the NCS that, in the long term, energy taxation would be developed towards promoting energy conservation and a consequent reduction in GHG emissions. Partly as a result of this, the government increased energy taxation slightly at the beginning of 2003.

Fuels used for transport and production of heat are taxed according to their  $CO_2$  content at a rate of  $\in 18.05$  per tonne of  $CO_2$ . However, natural gas receives a 50% rebate on this tax and peat is taxed using a different methodology, which results in lower taxes than would be the case when using the carbon content rate. Fuels used in the production of electricity are not taxed but the

electricity itself is taxed when delivered to the end-user. For combined heat and power (CHP) plants, taxes on fuels used for heat production are calculated assuming a plant efficiency of 111%. In addition to the  $CO_2$  tax, a separate duty, labelled the basic tax, is also levied on mineral oil products. All energy products are subject to the 22% value-added tax (VAT) and a supply security fee, also called a precautionary stock fee. Tax levels for various energy products are indicated in Table 1.

Fuel / I Iser	Basic Tax	Surtax <sup>2</sup>	Sunnly	VAT %
	Dusic Tux	Juntun	Security Fee	
Automotive diesel, cents per litre	26.83	4.76	0.35	22
Automotive gasoline, cents per litre	53.85	4.23	0.68	22
Light fuel oil, cents per litre	1.93	4.78	0.35	22
Heavy fuel oil, cents per litre	-	5.68	0.28	22
Hard coal, € per tonne	-	43.52	1.18	22
Natural gas, cents per m <sup>3</sup>	-	1.82	0.084	22
Peat, € per MWh	-	1.59	-	22
Electricity, € per MWh – residences	-	7.30	0.13	22
Electricity, € per MWh – industry	-	4.40	0.13	22

#### Finnish Energy Taxation, Q1 20031

\_ Table 1

1. Please note the changes in units for each of the energy products.

2. For the fuels included in this table, the "surtax" refers to the carbon tax of €18.05 per tonne of  $CO_2$ .

Source: Ministry of Trade and Industry.

As a means of stimulating the use of renewable resources, certain electricity producers can apply for a partial tax rebate on the electricity they produce. These producers and the levels of their rebates are shown in Table 2.

Energy-intensive industries can apply for a partial rebate on their energy taxes, thereby improving their competitiveness in international markets. An enterprise is regarded as energy-intensive if the total amount of the excise duty on certain energy products (electricity, coal, natural gas, peat, oil products) paid by the enterprise or included in the purchase price of corresponding products acquired by the enterprise exceeds 3.7% of the value added. For the taxes paid in excess of this 3.7%, an enterprise can apply for a refund of 85% of excise duty paid on the products or included in their purchase prices. The refund is paid only for amounts exceeding €50 000.

#### Table 2

Fuel/Plant Technology	Rebate Level
Wind plant	6.90 € per MWh
Forest chip-fired plants	6.90 € per MWh
Recovered fuel plants (REF)	2.50 € per MWh
Small-scale hydro plant (< 1 MVA)	4.20 € per MWh
Wood or wood-based fuels	4.20 € per MWh
Small (< 40 MVA) peat-fired district heating plants	4.20 € per MWh
Selected waste gas and waste heat plants	4.20 € per MWh

#### Tax Rebates on Electricity Produced from Renewables

Source: Ministry of Trade and Industry.

Special reductions in energy taxes are not offered to companies that engage in voluntary agreements with the government to reduce their energy use or otherwise improve their energy efficiency.

## CRITIQUE

Finland uses a holistic approach to effectively integrate the multiple aspects of a successful energy policy. The government recognises the importance of the three E's – Energy security, Economic development and Environmental sustainability. It proactively seeks to manage the objectives of these three goals, which include the need for an efficient and economic energy sector that is motivated, where possible, by market reform and light-handed regulation; environmental concerns, primarily climate change obligations; and energy security, which is especially important given Finland's lack of substantial domestic fuels.

While the Ministry of Trade and Industry has ultimate responsibility for energy policy and initiates all new policy developments, other relevant ministries contribute through consultation and delegation of responsibilities. The National Climate Strategy, which was passed in June 2001 and shaped by the work of six different ministries, is a good example of this collaboration. Co-ordination among the ministries appears effective with open communication, shared information and a good understanding of the concerns that other ministries have on particular issues. Such a structure ensures that energy policy objectives are considered when policy is being developed.

Finland makes good use of international measures and approaches to energy policy. This international approach is especially commendable given Finland's distance from many potential energy trading partners. The country's lack of domestic resources requires significant imports, and efforts made to import these fuels from a variety of countries effectively increases Finland's energy security. In addition, the creation of the Nordic Power Market (Nordpool) represents an excellent use of international electricity trade as a means of reducing costs and enhancing system security.

Such internationalism in energy policy could even be expanded. Further coordination among the transmission system operators (TSOs), the competition authorities and the energy regulators of the Nordic countries would provide the best means of developing an effective energy policy, especially in regard to Nordpool and its integration issues. In addition, trading of emissions allowances in an international market will provide an important tool to meet Finland's obligations under the Kyoto Protocol in a cost-effective manner.

Finland has adopted a light-handed approach to energy regulation. The large majority of energy production, transformation, sales and consumption is governed by market forces rather than by government mandate or influence. Finland was one of the leaders in market reform of the electricity sector, opening the market to full competition in the 1990s. The current *ex post* regulatory approach gives electricity transmission and distribution companies considerable freedom to establish prices and terms for the use of their assets.

Such a light-handed approach has its advantages and disadvantages. In general, the market has performed very well in the absence of tight regulations and should be allowed to continue. However, in certain areas, additional regulatory interventions could be used to enhance the performance of the energy sector. In the case of electricity, the *ex post* regulatory approach means that very few of the transmission and distribution tariffs are reviewed. More regular reviews could act as a tool to increase the efficiency of these sectors which are still considered to be natural monopolies. Additional regulatory oversight could enhance efficiency in district heating, which is used extensively and effectively in Finland. The Finnish regulator, EMA, has a staff of only 16 people with a budget that currently limits its ability to expand the scope of its regulation.

Finland has a number of traits that make energy security particularly important. On the supply side, the country lacks substantial domestic fossil fuels and its geographical position limits the amount of energy interconnections it can feasibly construct. While imported fuels do not necessarily imply a greater energy security risk, high import levels do require monitoring. On the demand side, Finland's cold climate and the significance of its energy-intensive industry make the reliable supply of energy particularly important.

Finland has responded well to these energy security challenges. As for emergency preparedness, it has the stocks of imported fuels corresponding to five months' average consumption based on the Security of Supply Act. This is far beyond the IEA/IEP stock obligation in terms of volume and coverage.

Finland has a diverse mix of primary energy supplies, with five different fuels individually accounting for at least 10% of the country's TPES. Finland has relied on market mechanisms to ensure that sufficient capacity is available in the electricity sector. Finland's reformed electricity sector will be tested in the coming years as new capacity will be required to come on line. An independent nuclear facility and numerous, smaller CHP stations are being developed to meet this need. Electricity grids are interconnected and their markets are fully integrated. The market's response to the future need for capacity should be monitored. Another tool to enhance energy security is the extensive use of fuel-switching for natural gas. Although Finland's natural gas is imported only from Russia, the potential liability of such an import structure is mitigated by extensive fuel-switching capabilities and the compulsory oil stocks to replace gas in the case of a supply disruption.

#### RECOMMENDATIONS

The government of Finland should:

- Continue the country's holistic approach to energy policy, including the strategy of pursuing numerous goals in tandem and with successful co-ordination between relevant ministries.
- Continue to expand the international approach to reaching energy policy goals, particularly regarding interconnections and the most cost-effective means of meeting climate change obligations.
- Enhance the energy regulator's role through expansion of staff and budget, especially for electricity transmission and distribution and for district heating, in order to further improve the efficiencies of these sectors.
- Continue to augment the country's energy security of supply through emergency preparedness, market mechanisms in the electricity sector, fuel diversity and fuel-switching capabilities.

## **CLIMATE CHANGE EMISSIONS**

## CURRENT AND HISTORICAL GREENHOUSE GAS EMISSIONS

According to the "Burden Sharing Agreement" among EU countries, Finland has agreed to keep its greenhouse gas (GHG) emissions at 1990 levels during the 2008-2012 Kyoto target period. In 1990, Finland emitted approximately 77.2 Mt of CO<sub>2</sub> equivalent (CO<sub>2</sub> eq.). In 2000, emissions were slightly below that level at 75.4 Mt CO<sub>2</sub> eq., but rose considerably in 2001, reaching 80.9 Mt CO<sub>2</sub> eq., or 4.8% above the 1990 baseline. Initial indications are that they continued to rise in 2002, reaching approximately 9% above the 1990 levels.

In 2001,  $CO_2$  from the burning of fossil fuels accounted for 75% of total GHG emissions. These  $CO_2$  emissions have risen more than overall emissions. In 2001, they reached 60.5 Mt, 12% above the 1990 baseline figure of 53.9 Mt, and in 2002 they rose to 63 Mt, or 17% above the baseline figure. This constitutes a jump of 15% over a two-year period, a rapid increase that is discussed more below. In 2001, the largest percentage (43%) of  $CO_2$  emissions came from the burning of oil products. Coal contributed 27%, peat and natural gas each contributed 14% and 2% came from other sources. These percentage shares have been relatively steady since 1990. The most significant change has been natural gas's rise from 9% to 14% of total  $CO_2$  emissions and a corresponding decrease in the emissions share of oil and oil products.

Almost 39% of  $CO_2$  emissions comes from the production of electricity and heat at public plants. A further 6% comes from the production of electricity and heat at autoproducing plants, primarily co-generating units at energyintensive factories such as pulp and paper manufacturers. The combined emissions from these two sources have risen from 33% of total  $CO_2$  emissions in 1990 to 45%. Emissions from the direct use of energy at manufacturing facilities has declined in relative terms from 27% of the total in 1990 to 19% in 2001. Transport sector emissions have remained constant over that time at 21% of the national total, with emissions from the residential sector falling from 12% to 6%. The percentage of direct energy use, and hence emissions for the residential sector, is below what is found in many other IEA European countries, which in 2000 accounted for 13% of total  $CO_2$  emissions. The low figure in Finland, despite the cold climate, results from the country's extensive use of district heating systems where emissions are allocated to central plants rather than to individual homes.





Source: CO<sub>2</sub> Emissions from Fuel Combustion, IEA/OECD Paris, 2003.

## FACTORS INFLUENCING CO2 EMISSIONS

The almost 15% jump in Finland's CO<sub>2</sub> emissions from 2000 to 2002 illustrates the potential volatility of the country's emissions. This volatility results from a number of factors that are largely beyond the control of policymakers, the most important factor being the weather. Not only will more energy be required for heating if temperatures are below average, but Finland's electricity supply is heavily influenced by rain and snowfall throughout the Nordic region. These factors affect hydropower in Finland, which represents about 20% of the country's electricity, as well as the availability of inexpensive imported electricity from the other Nordic countries, primarily Norway. The second most important factor that influences Finland's emissions is the number of energy-intensive industries that compete in international markets, such as the pulp and paper industries and metals. If the international market prices were to fall or demand were to slacken along with the regional and/or global economies, then economic activity, and subsequently emissions, would decline. Conversely, increased industrial production would increase emissions. While these two factors - the weather and economic activity - affect the emissions paths of all countries, they are particularly important for Finland.

Another determinant of Finland's  $CO_2$  emissions is the production level of its nuclear plants. The two plants were upgraded in the 1990s to increase their output. Thus emission-free nuclear power replaced generation that came largely from coal-fired plants, resulting in lower emissions. This is one reason why Finland was below its 1990 emissions level in 2000. As nuclear facilities cannot feasibly be upgraded again, no further emissions reduction will occur.

## GHG PROJECTIONS

The development of Finland's NCS was based on a set of three model projections of GHG emissions, each using 2000 as a starting point and forecasting up to 2010. The first projection was the business-as-usual (BAU) case. Under this scenario, no Kyoto-related measures are enacted beyond what was already in place in 2000. Energy taxation levels are also assumed to remain unchanged. Finnish GDP growth is assumed to average 3% per year from 2000 to 2005 and 2% per year from 2006 to 2010. World fuel prices are assumed to remain stable. TPES and electricity consumption would increase by 0.9% and 1.2% per year respectively. Total GHG emissions would rise by 19% from 2000 to 2010, signifying that GHG emissions levels would be 15% above 1990 levels in 2010.

The government developed two alternative scenarios, KIO1 and KIO2, which included measures to curb GHG emissions. For both scenarios, the resulting average annual growth figures are about 0.55% for total energy consumption and 1% for electricity consumption. Energy taxes would be higher than in the base case, technological progress would be higher, and there would be an

increase in renewable energy use. KIO1 assumed that natural gas would meet a significant portion of both existing and new electricity demand, while KIO2 assumed that a new nuclear plant would meet existing and new electricity demand. Both scenarios projected that total GHG emissions would decrease by 9% from 2000 and 2010, enabling Finland to meet its Kyoto targets. Finland has opted for more nuclear power rather than additional natural gas use, so that the KIO2 scenario is now the relevant forecast.

## CLIMATE CHANGE STRATEGY

#### **OVERALL STRATEGY**

Climate change mitigation is Finland's primary environmental priority. In 1999, the government began preparations for the National Climate Strategy (NCS), which it adopted and submitted to Parliament on 15 March 2001. The Parliament officially supported the NCS as the country's strategic framework for reducing GHG emissions on 19 June 2001. Finland signed the Kyoto Protocol on 29 May 1998.

The NCS was developed by an interministerial group chaired by MTI. The Ministry of Transport and Communications (MTC), the Ministry of Agriculture and Forestry, the Ministry of the Environment (ME), the Ministry of Finance and the Ministry of Foreign Affairs were also heavily involved in formulating the NCS. The interministerial group consulted regularly with stakeholders through the presentation of drafts and strategies to both industry and the public. In November 2001, MTI published the "Application of the Kyoto Mechanisms in Finland's Climate Policy," a report from the Finnish Committee on the Kyoto Mechanisms, and in April 2003 published an update on the progress, the "Implementation of the National Climate Strategy".

The measures included in the NCS are envisioned to reduce GHG emissions in 2010 by between 14 and 20 Mt  $CO_2$  eq. The breakdown of reductions by type of measure is shown in the table below.

Table	3

#### Effects of Climate Change Measures

Set of Measures	Expected Emissions Reductions by 2010 (Mt $CO_2$ eq.)
Energy conservation	3 - 4
Renewable energy	4 - 5
Change in source of electricity supply	6 - 10
GHG other than $CO_2$	1
Total	14 - 20

Source: National Climate Strategy, May 2001.

While there is some uncertainty within the projections regarding emissions reductions for each set of measures, the basic NCS framework sets out to achieve half of the needed cuts through increased energy conservation and renewable energy use, and half through a modification in Finland's electricity sources, moving away from coal to either natural gas or nuclear power.

# ENERGY CONSERVATION AND RENEWABLE ENERGY MEASURES

#### **Energy Conservation**

The NCS states that the increase in energy consumption will be curbed by all available means, taking into account the effects on employment and regional economies. The NCS envisions that an additional  $\in$ 13 million of public funds would be spent on energy conservation per year, bringing the total to  $\notin$ 59 million per year. The steps endorsed in the NCS and progress on their implementation as of April 2003 are as follows:

**Development of Energy Efficiency Technology:** The NCS endorses funding research in energy-efficient technology and product development, and maintaining the aid for commercialisation projects of new energy technology and case studies at least at its current level. Energy conservation and energy efficiency belong to one of the four fields in which the National Technology Agency, Tekes, operates. In 2001, Tekes spent €23 million in this field. More detail is provided in Chapter 10 on energy R&D.

**Higher Energy Taxes:** The NCS endorses energy taxation as one long-term tool for reducing energy consumption. Energy taxes were increased in the first quarter of 2003 with the objective to reduce energy consumption and therefore cut emissions. These increases are discussed in the energy taxation section of Chapter 3.

**Energy Conservation Agreements:** The NCS endorses extending the scope of existing voluntary energy conservation agreements with the implementation of further agreements to be made more efficient. These agreements have been strengthened and expanded and are discussed in greater length in Chapter 5 on energy efficiency.

**Statutes, Regulations and Guidelines:** The NCS calls for the drafting of a general act on energy conservation with its effects to be studied. It also calls for new energy efficiency norms for energy-consuming equipment. The Action Plan for Energy Efficiency was adopted in autumn 2000. Many of its energy-saving measures are now integrated into the NCS.

Information Dissemination and Training: The NCS calls for teacher training in energy conservation issues and improved efficiency in the collection of energy conservation data. In 2002,  $\in$  3.4 million was earmarked for communication and information activities for the promotion of energy conservation and renewable energy.

#### Promotion of Renewable Energy

The NCS aims to diversify energy supply and direct it towards activities that produce less GHG emissions by using more renewable energy. By 2010, it intends to increase by 50% the amount of renewable energy produced in Finland from 1990 levels. The steps endorsed in the NCS and progress on their implementation as of April 2003 are described below:

**Development of Renewable Energy Technology:** The NCS calls for the promotion of research into renewable energy technology, product development and demonstration and commercialisation. Tekes has participated in projects involving biomass, wind energy, solar energy and heat pumps. The government has provided annual funding for renewable energy technology of €10 million.

**Energy Taxation:** The NCS calls for the continuation of a tax structure favouring electricity generated from renewable sources. Further changes to the tax system supporting renewables were implemented in the first quarter of 2003.

**Investment Aid:** The NCS endorses investment aid to selected renewable energy projects as a means to partially offset the initial capital cost of these systems, thereby encouraging new plants. Such an investment credit scheme is currently in place and is discussed in detail in Chapter 6 on renewable energy.

**Information Dissemination and Training:** The NCS calls for increased education and training in matters related to the planning and use of renewable energy. In 2002, approximately  $\leq 0.6$  million was spent on information dissemination. In addition, the government has established a network of energy offices that promote renewable energy sources at the regional and local levels.

## CHANGES IN ELECTRICITY SOURCES

Substantially changing Finland's electricity sources was the other major NCS policy, intended to account for 50% of the envisaged GHG emissions cuts. The NCS proposed the following two options to achieve this:

- Cutting off coal power by legislative means.
- Approving the construction of an additional nuclear power plant.

The first option calls for a prohibition on the construction of new coal-fired capacity and the obstruction of generation from existing coal-fired plants. Electricity would instead come primarily from new plants fired by natural gas.

However, the government has decided to pursue the second option *(i.e.* additional new capacity). In May 2002, the Parliament approved the government's decision-in-principle for an independent largely private company to build a new nuclear reactor between 1 GW and 1.6 GW (Finnish nuclear power and the development of this new facility are discussed in greater length in Chapter 9). The new plant is scheduled to come on line in 2009. When approving the decision-in-principle, the Parliament obliged the government to make proposals on how to limit the use of coal in heat and power production in a controlled and co-ordinated way and how to enforce and enhance if necessary the renewable energy and energy efficiency programmes. A government committee was set up in late 2002 to limit coal use. The committee is to present its conclusions and proposals in December 2003.

## INTERNATIONAL EMISSIONS REDUCTION METHODS

The NCS discusses the possibilities offered by the Kyoto flexible mechanisms<sup>1</sup>. It acknowledges the benefits such tools can offer in lowering the cost of GHG emissions reductions. However, the possibilities for emissions reductions through flexible mechanisms are not explicitly quantified in the NCS.

In November 2001, MTI published the "Application of the Kyoto Mechanisms in Finland's Climate Policy." This report confirms the NCS position that flexible mechanisms may enhance the cost-effectiveness of cutting emissions. Nevertheless, it states that, owing to the uncertainties related to flexible mechanisms, the Finnish climate change strategy should be based primarily on domestic abatement measures.

The use of Kyoto flexible mechanisms is further explored in MTI's April 2003 publication, "Implementation of the National Climate Strategy". Regarding project-based mechanisms, the report describes pilot programmes for JI and CDM projects, which are led by the Ministry of Foreign Affairs and have been appropriated €20 million. The NCS states that €5.9 million has been earmarked for JI projects and €2.5 million for CDM projects. Around 30 such potential bilateral projects are being considered under these pilot programmes. Finland has also invested about €10 million in the World Bank's Prototype Carbon Fund and is expecting to receive credit for around 1.5 Mt  $CO_2$  eq. of emissions cuts for the first Kyoto commitment period and 0.2 to 0.5 Mt  $CO_2$  eq. thereafter from JI and CDM projects implemented so far.

Regarding emissions trading, Finland would be part of any EU-wide emissions trading scheme as envisioned in the GHG Allowance Trading Directive adopted

<sup>1.</sup> These include the project-based mechanisms of Joint Implementation (JI) and Clean Development Mechanisms (CDM) as well as international emissions trading.

in July 2003. The government realises that emissions trading under this EU scheme will be nationally transposed in order to eventually integrate the scheme into the NCS. The Finnish government is currently reviewing different methodologies for allocating emissions among qualifying facilities. A working group has been established for this purpose, which includes representatives from the ministries and the Energy Market Authority as well as from the sectors that fall within the trading scheme. In addition to allocation methods, the working group is also investigating how the allowance scheme would work with Finland's existing or planned domestic measures and how to ensure that it does not place Finnish industry at a disadvantage in the international market. The working group convened for the first time on 10 April 2003 and will end in March 2004, after which there will be hearings with the matter ultimately being handled at the ministerial level.

#### **OTHER ENVIRONMENTAL ISSUES**

Finland introduced new legislation, regulations and other measures against air pollution in the early 1980s, because its acid depositions were far above the amount that the soil can tolerate (critical load) and owing to air quality problems in some densely populated and industrialised regions. The legislative and other measures enacted at the end of the 1980s and start of the 1990s reduced Finland's SO<sub>2</sub> emissions and turned its NO<sub>x</sub> emissions onto a downward trend. Air quality in Finland currently meets the EU norms (Directives 1999/30/EC and 2000/69/EC) by a wide margin.

Finland still faces problems with fulfilling the domestic and EU targets for certain emissions. The emissions of NO<sub>x</sub> and of volatile organic compounds (VOCs) do not yet meet the requirements of the United Nations Economic Commission for Europe (UNECE) Emission Ceiling Agreement and those of the EU National Emission Ceiling Directive (2001/81/EC). Especially the emissions from transport, both for NO<sub>x</sub> and VOCs, which have remained high because cars in Finland are relatively old.

## CRITIQUE

As is the case for many IEA countries, Finland's greatest energy-related environmental challenge is the successful and cost-effective curtailment of GHG emissions, primarily  $CO_2$  from the burning of fossil fuels. Although Finland emitted less GHGs in 2000 than in the 1990 base year, those emission levels were anomalous owing to unusual or one-off circumstances. The emissions rose dramatically in the following two years, reaching an estimated 9% above 1990 levels in 2002. While weather conditions in 2002 – an unusually cold winter and dry summer – may not be repeated, emissions are likely to rise under
business-as-usual conditions. This will make meeting the country's Kyoto targets a very important challenge for Finnish energy policy.

The adoption and implementation of Finland's NCS is a commendable first step in addressing this challenge. The NCS was wisely drafted through an extensive consultative process involving various ministries and private stakeholders. It looks across the full range of emissions-producing sectors to seek all possible reductions. Implementation of the two main components of the strategy – energy efficiency plus renewable energy and new sources of electricity – is proceeding well. Both energy efficiency and renewable energy are receiving considerable attention. It is commendable that in 2002 the government further strengthened its Action Plan for Energy Efficiency and Renewable Energy. A relatively quick decision on the new nuclear facility and the ratification by the Parliament may help lower emissions during the first Kyoto commitment period.

While reports assessing the implementation of the NCS measures are helpful, future analyses may benefit from efforts to quantify the extent to which already implemented measures are actually cutting emissions. Such information could help policy-makers assess the relative effectiveness of different measures and determine the overall progress towards the Kyoto target. Part of this assessment could usefully include a new set of emissions projections up to 2010, enhanced by further experience and data reflecting the unanticipated rise in emissions seen in the last two years.

Finland's preference for domestic rather than international measures is a prudent choice. The cost of domestic measures, while not completely certain, is more predictable than the as-yet fully developed international carbon markets. Over-reliance on emissions cuts derived from flexible mechanisms could be risky. In addition, establishing the capacity to cut emissions through domestic means could be very important beyond Kyoto when additional cuts may be called for. It should also be noted that domestic measures promoting energy efficiency and renewable energy will contribute to energy security.

Nevertheless, flexible mechanisms will probably be extremely useful for Finland and should be accepted as a likely tool for cutting emissions, especially given that a large portion of Finland's emission cuts are projected to come from the new nuclear plant. While the Parliament ratified the government's decision-inprinciple in favour of proceeding with plans for a new nuclear reactor, its development and construction could still be affected by various factors, and any delay in its realisation will have a significant impact on the achievement of the NCS. Therefore, the government must closely monitor the progress of this plant. If the commercial operation of the nuclear facility were delayed, flexible mechanisms would have to be used to make up the difference since it would almost certainly be too late at that point to introduce additional domestic measures. Other factors beyond the control of policy-makers – weather and economic activity – will also affect emissions, thus creating further uncertainty that flexible mechanisms can more adequately address than domestic measures. Consequently, Finland is well advised to prepare for the effective use of such international tools.

Finland is exploring both the project-based and the emissions trading flexible mechanisms, and it is certainly proper to assess all such options at this point. However, a more complete analysis of the relative cost-effectiveness of these two tools may help the country determine whether projects or emissions trading offer the least costly way to acquire emission credits.

The forthcoming EU directive on emissions trading will be very important for all emitting facilities, particularly those in the energy sector. Finland is currently examining the implications for such a scheme within the national context and is encouraged to continue in these efforts. Perhaps the most important issue to be resolved is the methodology for allocating emission allowances. This must be done in an equitable manner across all emitting sectors and facilities and must take into account the actual efficiency of each facility. While all emitters must be motivated to reduce emissions, it would not be fair or effective to require the most efficient systems to reduce emissions by the same amount as the least efficient systems. In addition, new entrants, such as newly built power plants, should be able to acquire allowances at terms and prices that do not favour the incumbent, grand-fathered facilities. The need to acquire allowances should in no way become a barrier to entry for new competitors. Lastly, the relation between the emissions trading scheme and other NCS measures, such as energy taxation and voluntary agreements with industry, is not yet sufficiently clear. These measures may be redundant with the emissions trading scheme, but their removal could cause additional problems since the government depends on energy tax revenues and the voluntary agreements have been largely successful. Their contribution to other policy objectives, such as energy security, should also be taken into account. The government is encouraged to continue its study of these issues with the necessary resources to produce an accurate and timely analysis of the best way to integrate the emissions trading scheme into Finland's overall climate change strategy.

## RECOMMENDATIONS

The government of Finland should:

• Proceed with the implementation of the energy efficiency and renewable energy elements of the NCS in order to effect the needed changes by the time of the first Kyoto commitment window.

- ▶ Continue to undertake energy supply-demand and CO₂ emissions projections, evaluate the progress of the NCS and update it as required to achieve the Kyoto target in the most cost-effective manner.
- Closely follow the development of the fifth nuclear power reactor and consider alternative emissions reduction plans in the event that the planned nuclear facility does not come on line in the expected time frame.
- Review the package of measures on the supplementary role that emissions trading can play, particularly regarding potential overlaps with domestic measures.
- Determine a framework for allocation of emissions allowances in the relevant sectors as soon as possible.
- Assess the advantages, particularly in terms of cost-effectiveness, of the application of joint implementation and clean development mechanisms.

# ENERGY INTENSITY AND ENERGY EFFICIENCY

In 2001, Finnish aggregate energy intensity, as measured by a ratio of the country's TPES in tonnes of oil equivalent (toe) over its national GDP (in thousands of 1995 US\$ PPP), was 0.27 toe per US\$ 1 000. This was 51% higher than the average for IEA European countries, 26% higher than Norway and 15% higher than Sweden. Other national energy intensity figures such as TFC/GDP and per capita TPES are also higher for Finland than for IEA Europe and the other Nordic countries. In 2001, Finnish TPES per capita was 6.5 toe per person, while in Norway and Sweden it was 5.9 toe and 5.7 toe, respectively. In the same year, TFC/GDP in Finland was 0.20 toe per thousand US\$ of GDP at 1995 prices and purchasing power parities, while it was 0.17 toe in Norway and 0.16 toe in Sweden.

However, the use of such aggregate figures paints a somewhat distorted picture of the true efficiency levels of the Finnish economy and society. Finland has two qualities that substantially increase its energy use. The first is the country's cold climate. Finland has over 20% more heating degree days (weighted by population) than either Sweden or Norway. The second factor is the large number of energy-intensive industries in Finland. The basic metals, pulp and paper, chemicals and non-metallic minerals industries together consume 80% of all industrial energy use, while accounting for only 40% of the total industrial GDP. In recent years, structural shifts in the economy have lessened the effect such energy-intensive industries have on national energy intensity, but they remain an important component of the economy and act to raise Finland's energy intensity figures.

Data on Finnish space heating demonstrate the effect of the cold climate. Without adjusting for climate, space heating energy use in Finland is 60% above the average space heating in a selection of IEA countries<sup>2</sup>. However, if one adjusts for climate, the Finnish space heating is only 8% above the average in those other countries and even lower than countries such as France and the United Kingdom (UK)<sup>3</sup>.

Other figures suggest that Finland is more energy-efficient than comparable countries. For example, in 1999 the Finnish basic metals industry used 33.5 MJ of energy per 1995 US<sup>4</sup> of value-added product. This compares favourably

<sup>2.</sup> Canada, Denmark, France, Japan, Norway, Sweden, UK and US. Space heating efficiency measured as amount of energy used per square metre of heated space.

<sup>3.</sup> Data come from the IEA Energy Efficiency Indicators Database.

<sup>4.</sup> All energy intensity exchange rates converted using purchasing power parity (PPP) methodology, unless otherwise stated. Data come from the IEA Energy Efficiency Indicators Database.

with other metals-producing countries such as France (54.3 MJ per US\$), Germany (43.8 MJ per US\$) and Japan (41.8 MJ per US\$). Similar results are found in the pulp and paper industry where in 1999, Finnish companies consumed 41.7 MJ of energy per 1995 US\$ of value-added product. This compares to higher values for Canada (72.0 MJ per US\$), Norway (54.1 MJ per US\$) and Sweden (51.6 MJ per US\$).

Trends show that Finnish aggregate energy intensity is falling at rates equal to those of comparable countries. From 1991 to 2001, the national energy intensities of Finland, Canada, Germany, Norway and Sweden all fell between 13% and 15%. The drop in energy intensity for IEA Europe as a whole was 10.5%.

## DISTRICT HEATING AND COMBINED HEAT AND POWER

Finland makes extensive use of combined heat and power (CHP) technology. CHP facilities can be divided into two categories: *i*) plants that generate steam for district heating and electricity to be sold to suppliers or retailers, and *ii*) inside-the-fence plants that primarily serve the steam and electricity loads of industrial facilities.

CHP plants use heat from the power generation process and can be up to 90% efficient, whereas power-only plants deliver around 40% efficiency<sup>5</sup>. Thus, their extensive use improves the country's energy efficiency as a whole and consequently decreases GHG emissions. Their use is essential to the country's electricity system. In 2001, 31% of all electricity consumed in Finland came from CHP plants, 17% from district heating facilities and 14% from industrial inside-the-fence facilities. CHP plants accounted for over 70% of all fossil fuel- and biomass-fired domestically generated electricity (*i.e.* removing nuclear, hydro and imports). According to the European Commission<sup>6</sup>, only Denmark and the Netherlands had greater percentage contributions from CHP to their total electricity supply shares and they are both countries without hydro or nuclear power. The average CHP contribution to domestic electricity consumption among the EU countries is 9.8%.

#### DISTRICT HEATING

In 2001, district heating served 87 900 customers, 56% of which were residences, 34% offices or public buildings, and 10% industrial plants. The total building volume of customers was 675 million m<sup>3</sup> and the combined length of the delivery networks was 8 700 km. In 2001, district heating served 49% of the total space heating market, followed by light fuel oil (18%), electricity (16%)

<sup>5.</sup> This 40% efficiency figure applies to plants that use solid fuels and steam boilers. Combined-cycle gas turbine plants can reach 60% efficiency on a power-only basis.

<sup>6.</sup> EU Energy and Transport in Figures, Statistical pocketbook 2002.

and wood (12%). In 2001, connected heat load increased by 3.2%. Nearly 97% of new apartment buildings use district heating, between 55% and 60% of new terraced houses and about 10% of new single-family homes.

Seventy-five per cent of all heat generated for district heating systems comes from CHP plants and 25% from heat-only boilers. As of 2001, there were 82 cogeneration facilities selling steam and hot water to district heating systems. Together these facilities had 6 580 MW of heat capacity and 4 300 MW of electricity capacity. In addition, there were 495 stationary plants that produced just heat with a total capacity of 10 320 MW and 400 transportable heat-only plants with a total capacity of 1 300 MW. In 2002, the total district heating system had a heating capacity of 18 200 MW and produced 32.0 TWh of heat.

Fuel use for district heating systems in 2002 is shown in Figure 5.



Source: Finnish District Heating Association (Suomen Kaukolampö ry).

Historical fuel use trends demonstrate that natural gas use is expanding, primarily at the expense of fuel oil. In the future, gas use is expected to continue to grow although this will be limited by the geographical scope of the natural gas network. In 2001, 51 500 GWh of fuel were consumed, and 30 200 GWh of heat and 13 400 GWh of electricity were produced, for an overall system efficiency of 85%.

Nearly 75% of the all district heating operations are limited liability companies (LLCs). For the most part, these LLCs are wholly or majority-owned by municipalities, although they are profit-seeking ventures. Nearly 15% of district heating operations

are owned directly by the municipalities and 8% are public utility companies. District heating is subject to no *ex ante* regulation. Companies are free to set tariffs as they wish, although these prices are limited by competition from alternative heating systems, such as individual heating boilers and electric heating. Private consumers can complain about the tariffs or terms to the National Consumer Administration. The Finnish Competition Authority interprets the legislation to state that district heating companies (including district heating related to CHP) are considered to be in a so-called dominant market position towards their clients. Competition legislation prohibits the misuse of the dominant market position, which would include inter alia unfair treatment of customers, unreasonably high profits, cross-subsidisation between different activities of the company and other market abuses. Within a single district heating system, the tariff structure is the same for all customers (*i.e.* residential, industrial, public, etc.). However, tariffs vary considerably from system to system owing primarily to the differences in the capital and maintenance requirements for the delivery networks. In 2001, the weighted average price for heating was €36.60 per MWh and the arithmetical average was  $\in$  42.00 per MWh. Prices range from a low of  $\in$  30 per MWh to a high of almost twice that amount at €56 per MWh.

## INDUSTRIAL CHP PLANTS

In 2002, industrial CHP electricity capacity was 1 780 MW with a production in that year of 12.3 TWh. The capacity for heat production in the industrial CHP facilities was about 6 500 MW in 2002 with heat production of approximately 50 TWh.

The majority of such facilities are located at pulp and paper plants although they are also used in the basic metals, chemicals, oil refining and food industries. In 2001, wood-based fuels accounted for 67% of the fuels used in these plants, followed by gas at 16%, oil at 8%, peat at 6% and coal at 3%.

Industrial CHP systems have been very successful for the companies using them. There has been a shift in recent years from ownership by the industrial facility to ownership by an external energy company. A number of companies are considering new plants or efficiency upgrades to existing plants. Industrial CHP is thus expected to grow and maintain at least its current share of the national electricity market.

# **GOVERNMENT POLICY AND INSTITUTIONS**

## GENERAL POLICIES AND INSTITUTIONS

Energy efficiency has long been an important component of Finnish energy policy. The need to reduce GHG emissions now places greater importance on this objective. The National Climate Strategy (NCS) is based on a commitment

to the efficient use of energy as laid out in the Action Plan for Energy Efficiency adopted in the autumn of 2000. In December 2002, a working group on energy efficiency and renewable energy submitted its proposals for enhancing the Action Plan. The priority activities in the Action Plan include the following:

- Development and commercialisation of energy-efficient technologies.
- Further development of the building codes and other normative measures.
- Development and wider use of voluntary agreements.
- Further development and promotion of energy audit activities.
- Targeted information activities.

Table 4 shows the targets for energy savings under the proposed efficiency measures.

Energy Efficiency Targets				
Energy Source	2001 Consumption	2010 Baseline Scenario	Targeted Savings by 2010	Targeted Savings by 2010 (%)
Electricity (TWh)	81.2	90.5	2.4 - 3.7	3 - 4
Fuels (Mtoe)	29.0	31.7	1.6 - 2.4	5 - 7
Primary energy (Mtoe)	46.5	51.5	2.1 - 3.3	4 - 6

#### \_\_\_\_\_ Table 4 Energy Efficiency Targets

Source: Ministry of Trade and Industry.

The Ministry of Trade and Industry (MTI) leads the government's energy efficiency efforts. In addition to providing the guiding principles and leadership, it also signs all voluntary energy conservation agreements with industry (described below). Motiva also plays a key role in national energy conservation efforts. Funded primarily by MTI, Motiva produces and disseminates information on the necessity of conserving energy, energy-conscious operating models and available technical solutions. Motiva develops, promotes and monitors the conservation agreement system, conducts energy audits and analyses, and develops and markets methods for improving energy efficiency.

## **VOLUNTARY AGREEMENTS**

The government uses voluntary energy conservation agreements to encourage energy efficiency across the economy. Organisations in various sectors sign agreements in which their member companies agree to take certain actions



\* agreement concluded 2001.

\*\* agreement concluded 2002.

Source: Motiva Oy, February 2003.

such as analysing energy consumption, drawing up plans for improved energy efficiency and taking energy efficiency into account when making investments or procurements. Some of these agreements include specific targets such as percentage improvements in energy efficiency.

By the end of 2002, nine energy conservation agreements were in force. In autumn 1997, energy conservation agreements were signed by the Confederation of Finnish Industry and Employers (TT), the Association of Finnish Local and Regional Authorities, the Finnish Energy Industries Federation (Finergy), the Finnish District Heating Association (FDHA) and the Finnish Electricity Association (SENER). In 1999, the Finnish Association of Building Owners (RAKLI) and the Finnish Trucking Association (SKAL) both signed agreements. In March 2001, an agreement was concluded with the bus and coach sector. In July 2002, the Finnish Oil and Gas Federation and the Finnish Oil and Gas Heating Association signed a co-operation programme on furthering energy conservation in oil-heated properties, thus continuing the co-operation programme launched in 1997. In November 2002, the Federation of Housing and Property Owners and Developers (ASRA) signed an agreement. This last agreement is the responsibility of the Ministry of the Environment. All agreements are valid until 2005 except for ASRA's agreement, which runs through 2012.

The companies participating in such agreements account for more than 55% of Finland's total energy consumption, which includes both energy end-use and losses associated with electricity and heat generation. Figure 6 shows the coverage of energy conservation agreements for various sectors at the end of 2002.

#### **Energy Auditing**

A central objective of the voluntary agreements is to encourage energy audits and analyses. Audits are conducted by experts who identify potential ways of achieving savings in the areas of heating, water consumption, electricity and air-conditioning. Motiva is responsible for the development, marketing and quality assurance of audit activity and for training the auditors. MTI subsidises at most between 40% and 50% of the total cost of the energy audits.

Since 1999, more than 90% of new energy audits were conducted by companies that had signed energy conservation agreements. The number of audits taking place under the rubric of the voluntary agreements has risen steadily since 1998, when 199 audits were performed, until 2002 when 566 audits were performed. Table 5 shows the audits performed in various sectors from 1998 to 2002 and includes information on costs and subsidies for the audits. (This table does not include information on audits taking place outside the rubric of the voluntary agreements. In 2001, energy audits implemented outside the rubric of voluntary agreements generated savings of 0.2 TWh to 0.3 TWh.)

# Energy Audits Performed through Voluntary Agreements, 1998 to 2002

Sector	Number of Audits	Costs of Audits € million	Subsidy Granted by MTI € million
Industry	319	9.54	4.59
Energy	81	1.33	0.65
Municipal	818	3.01	1.49
Property and building	347	1.77	0.78
Transportation	4	0.01	0.01
Total	1 569	15.66	7.51

Source: Motiva Oy, February 2003.

#### **Investment Subsidies**

MTI also supports conservation through subsidies for energy efficiency investments. The main emphasis is on the introduction of new technology, which improves energy efficiency or uses renewable energy sources. However, companies that have signed voluntary agreements can, in certain cases, receive investment support for projects representing conventional energy conservation technology. In 2002, the maximum subsidy percentage for conventional energy conservation investments was 15% to 20%. The minimum amount of a subsidised project is €25 000 while the maximum subsidy to one company is €150 000 per year.

In 2002,  $\notin$ 2.1 million of investment subsidies were granted for 27 projects. Since 1998, 74 such projects have been supported with a total subsidy of  $\notin$ 4.1 million, of which industry received about 80%, municipalities 14% and the energy sector approximately 4%.

#### Third Party Financing

Energy service companies (ESCOs) provide an alternative means of implementing energy conservation measures. The ESCO assumes responsibility for the financing and technical implementation of energy efficiency projects and its investment is repaid through savings resulting from lower energy costs. Motiva started developing standard ESCO contract documents in 1997 and launched the first pilot project in the autumn of 1998. The model contract documents were released in 2000. In 2001, as part of Tekes's (National Technology Agency) Climtech programme, the Jumesco project was launched with the objective of implanting ESCO activity in the municipal sector. Although still in its early stages, ESCOs are becoming better known in Finland. In the next two to three years, Motiva expects ESCO activity to rise in Finland. In 2002, MTI treated investment subsidies for ESCO projects as model projects with the purpose of accelerating ESCO activity in the Finnish market.

#### Results

Finland's TFC for 2001 was 25.2 Mtoe, or 293.1 TWh. Measures implemented that year by companies having signed voluntary agreements resulted in energy savings of approximately 3.03 TWh per year, of which 0.56 TWh was electricity and 2.47 TWh was heating or fuels. More than 90% of these savings were realised in the industrial sector, 7% in the energy sector, slightly over 1% in the municipal sector and a negligible amount in the property and building sector.

Further measures that have been decided but not yet implemented would produce 1.22 TWh per year additional energy savings. By the end of 2005, Motiva estimates that the overall saving potential for sectors covered by the voluntary agreements is 11 TWh<sup>7</sup>, and that the savings effect of the agreements will exceed the estimated 5 TWh to 5.5 TWh per year by 2010, that is an energy use reduction of approximately 1.6% of the projected Finnish TFC in 2010.

# TRANSPORTATION

At the end of 2002, two voluntary energy conservation agreements were in force in the transport sector. The voluntary agreement in the lorry and van transport sector, signed in 1999, covered 10% of the sector's energy use at the end of 2001. The agreement is currently being evaluated and its continuation will depend on the findings of the evaluation. In 2001, a new energy conservation agreement was launched in the bus and coach sector.

The main policy for improving energy efficiency in private cars is based on the EU policy (agreement on energy efficiency in the automobile industry, *i.e.* the ACEA/JAMA/KAMA agreement).

Motiva has initiated joint development projects with companies and organisations in the transport market and provides companies with support for demonstration and information dissemination. The objective of every project is to launch a commercial product. Examples of these projects are as follows:

• EcoDriving is an educational package to encourage energy-efficient driving. EcoDriving reduces the average driver's fuel consumption by 1.3 litres per 100 km.

<sup>7.</sup> This is a cumulative not an annual figure.

- The KEY driving habit training for heavy vehicles is included in the environmental management models of the lorry and delivery van sector and the bus and coach sector. Early results indicate that fuel use can be reduced by between 8% and 12%.
- Lowering fuel consumption in cars sold in Finland is encouraged by the organisation of an annual competition for the most ecological car.

#### BUILDINGS

In May 1999, MTI and the Finnish Association of Building Owners and Construction Clients signed an energy conservation agreement in the real estate and construction sectors.

In co-operation with the Association of Finnish Local and Regional Authorities, municipalities draft individual energy conservation agreements with MTI. Each municipality concluding such an agreement is committed to carry out measures similar to those taken by private companies. At the end of 2001, 62 municipalities were included in the system, with a 55% coverage of the sector.

The Ministry of the Environment is revising the Building Code to improve the energy efficiency of new buildings. These new regulations came into force in October 2003 and aim to improve the energy efficiency of new buildings by about 25%. Energy labelling and energy efficiency standards for domestic appliances have been implemented in accordance with EU principles. In 1995, energy labelling of refrigerators and freezers started in accordance with the EU labelling directives. Labelling of washing machines and tumble dryers started in 1996, washer-dryers in 1998 and dishwashers and household lamps in 2000. Minimum efficiency requirements for hot water boilers were implemented in 1998, for refrigerators and freezers in 2000, and for ballasts for fluorescent lighting in 2002.

## CRITIQUE

While nationally aggregated figures demonstrate that Finnish energy intensity is well above the IEA average and even above its Scandinavian neighbours, such figures are clearly influenced by Finland's cold climate and high proportion of energy-intensive industry. Other more detailed figures, as well as anecdotal evidence, suggest that Finnish industries and society have achieved a commendable level of energy efficiency. The distinction must be made between energy intensity, which is influenced by climate and economic structure and energy efficiency, which refers to the efficiency with which fuels can be turned into useful products or other forms of energy. While Finland is clearly energyintensive, it also appears to be energy-efficient in most sectors. In addition, its energy intensity is falling at a pace comparable with other countries. The extensive use of CHP plants for industrial and district heating uses helps to lower national energy intensity. Over 30% of all electricity consumed and over 70% of all fossil fuel-driven electricity come from CHP facilities. With the exception of smaller plants or plants using biomass, CHP use has spread without explicit government support. This trend is expected to continue both in the form of new greenfield plants and existing heat-only facilities being converted into CHP plants. Increased CHP use is an efficient and reliable way to meet Finland's growing electricity needs.

District heating operations are subject to very little regulation, which is in line with the government's light-handed approach to energy policy. While customers are free to choose any heating system they wish (*e.g.* district heating, electricity or fuel oil), district heating suppliers operate in a *de facto* monopoly situation in that one network will serve a given community. In this way, efficiencies and cost reductions will not be achieved through direct competition with other district heating companies. The limited oversight by regulatory authorities could allow district heating greater efficiency and reducing the threat of cross-subsidisation, the government should consider giving the Energy Market Authority additional control over district heating operations.

While district heating from CHP plants offers an energy-efficient means of space heating, the structure of the market may not be encouraging energy-efficient behaviour. Approximately 50% of all district heating goes to residences, principally apartment buildings. In general, heat is measured (and charged for) only at the building level because individual meters do not exist in each unit. Consequently, people living in apartments have, at best, a weak monetary incentive to curtail their space heating, which could come through enhanced insulation or changes in behaviour. While individual metering could be an expensive proposition, the costs of such an initiative must be measured against an expectation of the resulting energy savings.

Voluntary energy conservation agreements are the government's primary tool in encouraging energy efficiency. These agreements are an internationally accepted means of reducing energy use and are favoured by companies over stricter regulations or higher taxes. An impressive 55% of Finland's TFC is covered by such agreements. The savings achieved thus far in conjunction with the agreements are significant, nearly 1% of Finnish TFC. While companies may have pursued some energy efficiency improvements independently, a great deal of these savings can in any case be attributed directly to the agreements. While the voluntary agreements do require energy auditing and reporting, the majority of them do not lay out targets in relation to reasonable energy baseline projections. Consequently, it is difficult to fully assess to what extent these energy savings would have occurred in the absence of the agreements. The government may want to consider more accurate measurements along these lines. They may also want to consider binding or non-binding energy efficiency targets for companies based either on percentage improvements in energy efficiency or a benchmarking system. While this would require companies to take more action, it would increase the chances that energy efficiency targets are met, which will be particularly important since the NCS is relying on efficiency improvements for about 20% of the required emissions reductions. As discussed in Chapter 4 on energy and the environment, the future of this mechanism is highly dependent on how and when the EU emissions trading system will be implemented.

Certain sectors are more conducive to voluntary agreements than others. Industrial energy use can be addressed in this way, but the other sectors are not so straightforward. While 90% of industrial energy use is covered by voluntary agreements, other sectors have considerably lower coverage rates. Over 90% of the energy savings realised in conjunction with the agreements has come from the industrial sector. Applying voluntary agreements to other sectors may require altering the approach and take into account the particular characteristics of those sectors, or using entirely different methods.

The voluntary agreements must work with the recently adopted EU directive on GHG emissions trading. If the emissions trading scheme provides sufficient discipline to companies to lower their emissions (through lower energy use), the voluntary agreements may become redundant. Simultaneously, the future allocation of allowances may deter companies from making energy efficiency improvements now for fear of being punished later with lower emission allowance allocations. In addition, efficiency improvements now would make further improvements more difficult or costly. As a consequence, companies might prefer to delay the easier energy saving investments until allowances have been allocated. The interaction between these two systems needs to be clearly defined.

## RECOMMENDATIONS

The government of Finland should:

- Study the issue of cross-subsidies between district heating and electricity operations, and evaluate possibilities to improve transparency and competition in the district heating sector, starting with large heating networks. Consider the possibility of extending Energy Market Authority jurisdiction over the district heating sector.
- Expand the analysis of the energy efficiency aspects of heating choices in new residences.

- Examine the legal, economic and technical possibilities for developing heat metering in individual apartments that are currently billed according to static indicators on consumption, often with a flat fee.
- Review the use of voluntary agreements for industry in light of the European Union directive on emissions trading. Consider more stringent energy conservation targets in the agreements.
- Consider introducing more sophisticated economic signals that would favour a more fuel-efficient private car fleet, for example through an annual circulation tax or taxes on acquisition.
- Continue to encourage combined heat and power (CHP) production and new investment, especially for plants fuelled with renewable energy.

## CURRENT AND HISTORICAL PRODUCTION

In 2001, renewable energy represented 23% of Finland's TPES, against an average of 11.5% for IEA countries. During that year, Finland produced 7.8 Mtoe of renewable energy. Over the last 30 years, the share of renewables in TPES has remained relatively constant, ranging from a low of 17% in 1987 to a high of 24% in 2000. Renewables' share in TPES is influenced by annual changes in rainfall and snowfall as well as the business cycle of the wood-processing industry, which is a significant biomass producer.

Biomass is by far the largest renewable energy contributor in Finland, accounting for 85% of all renewable energy in 2001, followed by hydropower, which accounted for 15%. Other renewable resources also contributed to the energy mix, as shown in Table 6. Historical trends in renewable energy are shown in Figure 8.

Renewable energy makes an important contribution to Finland's domestic energy production. In 2001, biomass and hydropower together accounted for 51% of the country's domestic production, or 84% of the total if nuclear is considered to be an import.

## **GOVERNMENT POLICY AND SUPPORT MECHANISMS**

In April 1999, MTI published the "Action Plan for Renewable Energy Sources". In December 2002, the plan was revised and the government published the "Action Plan for Renewable Energy Sources 2003-2006". The Plan identified the following four positive aspects of renewable energy for Finland's energy sector.

- Produces lower carbon emissions.
- Promotes indigenous resources, particularly biomass.
- Maintains a high level of energy technology.
- Ensures energy security of supply.

The Action Plan sets goals for increasing various types of renewable energy. These are shown in Table 6.

Renewable Energy Contributions to Total Primary Energy Supply in IEA Countries, 2002 – Figure 7







Renewa Technology Type	ble Ener	le Energy Targets in R 2001 2005		2010		2025	
	PJ	PJ	% increase from 2001	PJ	% increase from 2001	PJ	% increase from 2001
Bioenergy	267	305	14	349	31	414	55
Hydropower (> 10 MW)	42.8	44	2	45	4	46	8
Hydropower (< 10 MW)	4.1	6	39	8	88	11	175
Wind Power	0.25	1.2	5 times	4	16 times	17	70 times
Solar Power	0.021	0.16	8 times	0.33	16 times	3.3	200 times
Heat Pumps	2.73	4	55	7	147	16	6 times
Total	317	359	13	412	30	508	60

Table G

Source: Renewable Energy Sources in Finland 2002, OPET Report 9, Organisation for the Promotion of Energy Technologies (OPET), 2002.

The Action Plan's long-term objective is to make renewable energy sources as competitive as possible in the open energy market without continuous government support. In order to expedite such a scenario, the Action Plan promotes the following government measures, which have been implemented:

- **Development and Commercialisation of Technology:** The Action Plan cites the development and commercialisation of innovative technology as the most important long-term promotional measure. The Action Plan calls for a higher proportion of publicly-funded research to be spent on renewable technology development. It also states that when technologies have reached maturity, support for them should be reduced.
- Energy Taxation: The Action Plan stresses the importance of a tax system favouring renewable energy. It calls for the continuation of the tax system favouring renewables that was implemented in 1997.
- **Investment Aid:** The Action Plans endorses investment aid or subsidies of initial capital costs for innovative technologies with the objective to accelerate the commercialisation of such technologies and to improve the competitiveness of renewable energy sources.

In recent years, an increasing share of R&D financing has been devoted to renewable energy technologies; approximately  $\leq 10$  million has been allocated for this purpose (R&D is discussed in greater detail in Chapter 10). Tax rebates are given to electricity produced from selected renewable energy sources. According to the existing rebate scheme, the government estimates that tax rebates totalling approximately  $\leq 50$  million will be given to electricity produced from selected are included in the energy taxation section of Chapter 3.

In addition to the existing support mechanisms described above, the government is also considering alternative schemes to encourage greater electricity generation from renewable energy plants. In particular, it is exploring the use of green certificates, whereby providers of electricity would be required to obtain a number of green certificates corresponding to a certain percentage of electricity they deliver to customers. These green certificates would be obtained from renewable energy purchase obligations, whereby sellers of electricity would be obliged to source a certain percentage of the electricity sold from renewable energy plants. These could be plants that are owned either by themselves or by others.

Investment subsidies are given by the government to cover a percentage of the initial capital costs of renewable energy plants. The types and magnitudes of these subsidies are shown in Tables 7 and 8.



Technology	Subsidy, € millions	% of all subsidies
Wood-fired plants:		
Energy generation	18.3	55
Production of wood-based fuels	2.6	8
Wind power	7.3	22
Other renewables	0.84	3
Energy conservation Investments	2.4	7
Energy audits	1.76	5
Total	33.2	100

Source: Country submission.



#### Levels of Energy Subsidies, 2002

Technology/Project	Development Stage	Subsidy Level, % of capital costs
Use of wood energy:		
Heating plant < 5 MW	Conventional technology	10 - 20
Heating plant < 5 MW	New technology	20 - 30
Heating plant > 5 MW	Conventional technology	10 - 15
Heating plant > 5 MW	New technology	20 - 30
Small-scale CHP	Conventional technology	5 - 20
Small-scale CHP	New technology	10 - 40
Other:		
Wind power	Conventional technology	30 - 32
Wind power	New technology	33 - 40
Solar		30 - 40
Small-scale hydro		20 - 40
Landfill gas		20 - 40
Heat pumps		20 - 40
Conservation and efficiency:		
Investments	Conventional technology	20
Investments	New technology	20 - 40
Energy audits		35 - 40

Source: Country submission.

# CRITIQUE

The favourable aspects of renewable energy outlined in the Action Plan accurately reflect the benefits that such energy sources can bring. This is especially the case for Finland, which faces the challenge to reduce its GHG emissions and has no fossil fuel deposits but substantial renewable energy resources in the form of biomass. Finland has also shown an ability to successfully develop innovative technology, including energy systems, so commercialisation in that area could bring economic benefits beyond the energy sector.

The different renewable energy sources in Finland have widely varying characteristics. In 2001, biomass and hydropower accounted for 99.9%<sup>8</sup> of Finland's renewable electricity production. Biomass and large hydropower plants rely on Finland's favourable natural circumstances and have evolved with very little government support. While environmental constraints prohibit the development of new large-scale hydro plants, promising small-scale hydro sites have been identified around the country. A number of these sites will probably be developed, with the aid of government investment subsidies and tax rebates, although there are concerns that excessive licensing for such plants may add to the developers' costs and thus render certain locations uneconomic.

Biomass is poised to expand in Finland. The Action Plan envisions biomass providing 90% of the increase in renewable energy use by 2010. While Finland has substantial biomass resources in its extensive forests, biomass fuel prices tend to be higher than coal, peat and oil, and the capital costs tend to be higher for biomass plants than for plants running fossil fuels. The advantage of biomass lies in its net-zero emissions and its availability as a waste product from the many pulp and paper and timber manufacturing processes. Larger plant sizes improve the economics of biomass through economies of scale and some of these larger plants are being built in Finland. At the same time, the capital cost of smaller plants has fallen in recent years which, along with government support, should extend biomass use to areas or sectors that did not have sufficient demand or fuel to justify a larger plant. Nevertheless, growth will be limited by the cost disadvantage compared to fossil fuels (primarily coal) and the limits and costs related to the transport of biomass.

Finland's natural circumstances do not favour the other renewable energy technologies. Limited total sunlight, owing to Finland's geographical position, renders solar generation almost impossible during the winter months. While Finland does have some areas with substantial wind, the country's wind resources are not exceptional and the cold weather can interfere with equipment, increasing maintenance costs and reducing reliability.

<sup>8.</sup> This figure also includes small-scale hydropower. However, hydropower is dominated by the larger plants with 92% of domestically-generated hydroelectricity coming from plants larger than 10 MW, 7% coming from plants between 10 MW and 1 MW and less than 1% coming from plants with less than 1 MW of capacity.

The government's intention to increase wind power from 40 MW to 500 MW in less than ten years is highly ambitious. The current support schemes – investment subsidies and tax rebates – will help to achieve this increase but could be very costly. Although wind power received investment subsidies in 2002 of  $\notin$ 7.3 million, equal to between 30% and 40% of each new plant, and tax rebates of  $\notin$ 6.9 per MWh, the plants only produced 66 GWh or 0.017% of Finland's TPES. In addition, wind received 22% of the total renewable energy investment subsidies in 2002 while its production has actually fallen from 80 GWh in 2000 to 72 GWh in 2001 and then to 66 GWh in 2002. While these are the early days of wind power in Finland and support is currently intended to create a competitive industry in coming years, these costs nevertheless seem high. Given that Finland has no characteristics that favour wind power, it might be better to use limited support funds for biomass, which could offer the same environmental and security benefits with less support while being more suited to the country's natural, industrial and technological strengths.

Any support mechanism for renewables should have built-in mechanisms for reducing support levels as a means of encouraging greater efficiency in the private sector. The Action Plan calls for the eventual phasing-out of government support once renewable energy technologies become competitive, but no such phase-out is in place as part of the current system. It will be even more difficult to reduce support once industry begins to rely on subsidies and tax rebates. The transparency of the support system could be improved. The investment subsidy and tax rebate system do not make it clear how much Finnish taxpayers are paying to support renewable energy per unit of electricity they receive. Such a lack of transparency could lead to uninformed decision-making by either the public or policy-makers. Changing the support scheme or translating it into terms everyone can easily understand and assess would be helpful in this regard.

The government is considering green certificates and purchase obligations for grid operators as support schemes for renewables. Employing one of these schemes would be a positive step in promoting renewable energy while reducing technology costs and increasing efficiency in production. They would also be more compatible with the liberalised electricity market than the current renewable energy support mechanisms.

## RECOMMENDATIONS

The government of Finland should:

• Evaluate the existing support scheme for renewables with the aim of developing a market-based system that will achieve emissions reductions at

a minimal cost and give incentives to reduce production costs from renewables.

- Take measures to simplify and accelerate licensing and appeal procedures of wind and small hydropower plants.
- Explore measures to increase the economic supply of biomass.

#### COAL

In 2001, coal supply in Finland was 4.2 Mtoe, accounting for 12.4% of the country's TPES. From 2000 to 2001, coal supply to Finland increased by 10% owing to a rise in electricity demand and below-average hydroelectric generation. Over the last 30 years, coal's contribution to Finland's TPES has ranged from 10% to 18%. It is projected to account for 12% of TPES in 2010 and 14% in 2020. In 2001, 80% of coal consumed in Finland was used to generate electricity, with coal-fired power accounting for 15% of all electricity generation, while the remaining 20% was used by industry.

There is no coal production in Finland. Imports come from the international market. In 2001, 46% of the coal imported to Finland came from Russia, 32% from Poland and approximately 10% from North America.

Coal produces more  $CO_2$  emissions per unit of electricity generated than almost any other fuel or generation source. In an effort to curb  $CO_2$  and other GHG emissions, the government considered cutting off coal supply by legislative means, with the assumption that gas and other less carbon-intensive fuels would take its place. However, restrictions on coal use have not been implemented given that the government has decided instead to approve the development of a new nuclear plant as a means of producing electricity in Finland while still meeting the country's Kyoto targets.

#### PEAT

In 2001, the total supply of peat to Finland was 1.9 Mtoe, or 5.7% of national TPES. Peat is harvested domestically with no imports or exports of the fuel. From 1990 to 2001, peat was a small but stable contributor to the Finnish energy sector, accounting for between 4.2% to 7.2% of TPES. The government expects peat to continue to contribute approximately 5% of TPES through 2020.

Eighty-three per cent of peat is used in electricity production processes, principally in CHP plants that also produce heat for district heating or industrial processes, while the remaining 17% is used directly by industry. Peat is very often burned in conjunction with wood fuel (biomass) because the exclusive use of wood in a boiler can cause technological problems. The availability of wood is less stable than that of peat.

While the use of peat in electricity generation is ostensibly determined by financial factors on the open electricity markets, the government has stated

its aim to maintain the current level of peat use in the co-production of electricity and heat and in the exclusive production of heat. Towards that end, despite its significant GHG emissions, peat receives tax advantages that are not given to other fuels. The energy taxation policy aims to guarantee that peat will maintain its competitiveness compared to oil, gas and coal. The government ensures that fiscal policy towards peat (*e.g.* taxation or investment subsidies) does not lower its price to the extent that it would jeopardise the development of the energy use of forest residue chips.

Peat has a high carbon content and its combustion causes considerable  $CO_2$  emissions. Peat produces roughly 12% more  $CO_2$  per TJ than coal<sup>9</sup>, which itself has significantly higher  $CO_2$  emission rates than oil or natural gas. However, a life-cycle analysis of fuel emissions adds several factors to the comparison between fuels. If unharvested, peat bogs will absorb  $CO_2$  and emit  $CH_4$ ; the net effect of these factors is undetermined. Additionally, after the peat has been removed, the bogs can be afforested or allowed to revert to wetlands, in both cases providing carbon sinks. Given that there is no definitive study that quantifies the full life-cycle emissions effects of peat (or other fuels), this methodology for measuring emissions from different fuels is not widely accepted. The government has recently launched a research project to analyse life-cycle emissions of peat. Depending on the results of this research, Finland may try to propose a revision of the rules under the UN Framework Convention on Climate Change (UNFCCC) that govern the calculation of GHG emissions by fuel.

#### OIL

In 2001, oil represented 9.4 Mtoe or 28% of Finland's TPES. Oil's percentage share of TPES has fallen steadily since 1973 when it accounted for 64% of the total energy supply. This decrease was the consequence of a decline in oil use by industry and the replacement of oil by nuclear power as an electricity generating fuel. In 2001, oil was used to generate only 0.9% of the country's electricity; 53% of oil TFC went to the transport sector, with industry consuming 14% and residences consuming 12%.

Finland has no domestic crude oil production. Since July 1991, companies have been free to import oil to Finland. In 2001, Russia provided 48% of Finland's crude oil imports. Gasoline imports were 370 000 tonnes in 2001, representing 20% of gasoline sales. Norway was the most important source of

<sup>9.</sup> According to the methodology established in the *IPCC Guidelines for National Greenhouse Gas Inventories*, peat has a carbon content of 28.9 tonnes of CO<sub>2</sub> per TJ, and bituminous coal (the most commonly used coal type for electricity generation) has a carbon content of 25.8 tonnes of CO<sub>2</sub> per TJ.

imported gasoline, representing 53% of total imports. Finland has two oil refineries, Porvoo and Naantali, with a total refining capacity of about 240 000 b/d. Both refineries are owned by Fortum. In 2001, Fortum exported 4.8 Mt of oil products.



The most important oil company in the Finnish market is Fortum, which was established in 1998 in the merger of the oil company Neste and the power company IVO. Although Fortum has been partly privatised, the government still holds the majority (61%) of its shares. Fortum's activities include oil exploration, production, refining and distribution. Fortum provides most of the oil products on the Finnish market. In some of its oil activities Fortum is still using the brand Neste. Other oil companies, such as Shell and Esso (Exxon), are active in the distribution of oil products in Finland. In 2002, Neste's share of the gasoline market was 30%, Shell's 19% and Esso's 13%. In the diesel market, Neste's share was 43% followed by Teboil's 23% and Shell's 17%.

Finnish *ex-tax* prices for gasoline and diesel fuel are comparable to those in Scandinavia and the rest of Europe. Figures 10 and 11 show the *ex-tax* and full retail prices for gasoline and diesel fuel in OECD countries and Figure 12 shows the historical progression of prices in the Nordic countries.



Note: data not available for Korea and Mexico. Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.



– Figure

Note: Data not available for Canada, Korea, Mexico and Turk Source: *Energy Prices and Taxes*, IEA/OECD Paris, 2003.







Source: Energy Prices & Taxes, IEA/OECD Paris, 2003.

# EMERGENCY RESPONSE MEASURES

#### Legal Authority and Emergency Organisation

The Security of Supply Act, which was enacted in 1992, is the legal basis for ensuring supplies of various basic materials, including oil, in the case of emergency situations. According to the decision of the Council of State in May 2002, the target for stocks of imported fuels corresponds to five months' average consumption. The National Emergency Supply Agency (NESA), a subordinate agency to MTI, was founded for the development and maintenance of security of supply. Since the beginning of 1993, NESA has acted as Finland's stock holding agency.

MTI is responsible for issues related to security of supply in both normal and crisis situations. MTI is the core of Finland's National Emergency Sharing Organisation (NESO). NESO includes personnel from NESA and the National Board of Economic Defence. Industry experts in the Finnish Oil and Gas Federation are nominated on a stand-by basis to join NESO in case of an emergency.

#### **Emergency Reserves**

Finland has the following two categories of emergency reserves of crude oil and oil products to meet the IEA emergency reserve commitment.

- *Compulsory stocks* held by importers under the 1994 Compulsory Stockpiling of Imported Fuels Act. This stockholding obligation applies to crude oil, other refinery feedstock (*i.e.* gas condensates) and oil products. The obligation to hold stocks is on the importers. It is based on the actual net imports of each product and crude oil. The compulsory stock level is two months' average imports of the previous calendar year. The compulsory stocks are under the control of NESA.
- *State-owned stocks* held by NESA under the Security of Supply Act. Part of these stocks is held exclusively to meet the IEA stockholding obligation.

It is a general policy of the government to release compulsory stocks held by importers first. State stocks are generally not available until commercial industry stocks and the compulsory stocks have been used.

#### **Demand Restraint**

Although Finland maintains demand restraint measures in accordance with the Emergency Act and the Act on the Application of the IEP Agreement, the current policy favours stock drawdown. If stock drawdowns are insufficient to alleviate the supply shortages, demand restraint measures will be enacted.

## NATURAL GAS

#### SUPPLY AND DEMAND

In 2001, natural gas supply to Finland was 3.7 Mtoe, accounting for 11% of national TPES. Natural gas supply has steadily risen since it was introduced to Finland in 1974. Over 70% of natural gas used in Finland goes to the co-generation of power and heat. Natural gas consumption for 2002 is shown in Figure 13.



Source: Finnish Natural Gas Association.

While the government projects that gas will represent only 12% of TPES in both 2010 and 2020, the Finnish natural gas supplier, Gasum, estimates that its share could rise as high as 16% to 18% by 2020, which would mean a doubling of the current gas volume. The most promising area for expanding gas consumption lies in its further use in CHP plants. Whether new CHP plants opt for gas as a fuel or others fuel-switch to gas will depend on the rise in Finnish electricity demand and the country's need to lower GHG emissions. Growth in gas use is limited by the transportation pipeline, which cannot economically go north above a certain latitude where the population (and hence gas demand) is too sparse to economically justify it. In addition, home heating with gas is generally not viable because of competition from existing, inexpensive district heating schemes and electric heating. Finland has no domestic natural gas resources. Since the introduction of gas in 1974, all Finland's gas is imported from Russia. In 1994, Gasum signed a 20-year contract with Russia's Gazprom for supply of gas. The contract has take-or-pay minimum levels as well as options to increase the volume delivered and to extend the term past 2014. Pricing in the contract is tied to a basket of indices, including oil prices and domestic energy prices.

## MARKET AND REGULATORY STRUCTURE

The natural gas market in Finland is dominated by Gasum Oy. Gasum is responsible for all imports, transmission and sales on the wholesale level in Finland. The company ownership structure is as follows:

- Fortum (Finland) 25%
- Gazprom (Russia) 25%
- Finnish government 24%
- Ruhrgas (Germany) 20%
- Finnish forestry companies 6%

Gasum owns, maintains and operates the high-pressure transmission grid throughout Finland. It is also responsible for planning and construction or expansion of the pipeline network. The high-pressure transmission system, which was 1 000 km long in 2002, is shown in Figure 14.

Basic planning of an extension of the gas transmission system to the Turku economic zone in western Finland was completed in August 2002. Gasum anticipates that a pipeline of 50 cm in diameter would be needed to ensure adequate transmission capacity. Gasum aims to deliver natural gas to Turku by 2008.

Over 30 regional distribution companies sell gas to small-scale users, despite local distribution accounting for just under 5% of total consumption of natural gas. Gasum owns about 15% of these distribution companies.

Finland has some of the lowest gas prices in the IEA. In 2001, Finland had the cheapest *ex-tax* price for industry and the second-cheapest *ex-tax* prices for households. Figure 15 provides price information for IEA countries.

#### **Regulatory Structure**

Directive 98/30/EC of the European Parliament and the Council Concerning Common Rules for the Internal Market in Natural Gas gives Finland a derogation on the need for market opening because: *i*) Finland has only one



Source: Gasum Oy.

- Figure


#### **Industry Sector**



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



Household Sector

Note: Tax information not available for Canada and the United States. Data not available for Australia, Belgium, Germany, Greece, Italy, Japan, Korea, Norway and Sweden.

Source: Energy Prices and Taxes, IEA/OECD Paris, 2003.

natural gas supplier (Russia), and *ii*) Finland is not connected via gas transmission pipeline to the other EU countries. This derogation will remain in place until either of these conditions is no longer met, which is unlikely in the foreseeable future.

This derogation has resulted in the 2000 Finnish Natural Gas Market Act, which does not open the wholesale or retail sale of natural gas to competition. Gasum maintains the mandate as the sole supplier of natural gas in Finland. The tariffs charged by Gasum are *ex post* monitored by the Energy Market Authority (EMA). These tariffs include a supply component (reflecting the contract with Russia) and a transportation component, reflecting the capital and operating costs of the pipeline network. Complaints brought by gas consumers can prompt an EMA investigation into gas tariffs; however, this is rare. EMA uses no established methodology to assess tariffs charged by Gasum. However, Gasum does work with EMA in a sort of *ex ante* consultation before major expenditures to assure that the regulator approves of its plans.

A small unregulated secondary market of natural gas exists in Finland. Gas consumers and retailers with annual purchases of at least 5 million m<sup>3</sup> are eligible to participate. These eligible customers can offer gas, which they receive under a contract with Gasum and do not need themselves, to the secondary market or they can offer to buy gas from the secondary market. A special gas exchange, Kaasupörssi, has been set up, including a web site that provides a trading place for buyers and sellers. In 2002, this secondary market accounted for 0.8% of all gas consumed in Finland.

#### **Alternative Supply Sources**

The single supply source (Russia) for natural gas raises energy security concerns. However, as noted in the section on the security of energy supply in Chapter 3, Finland has taken serious steps to address this issue. Steps include on-site backup fuel for 90% of gas consumption and the ability to serve 350 MW of load with a propane-air mixture for customers lacking suitable backup. Gas supply from Russia has been strong and reliables since the introduction of gas in 1974. Although Finland has no gas storage, owing to a lack of depleted gas fields and suitable geology, the pipeline can store about one-half day's worth of demand.

Finland has for some time examined alternative natural gas supply routes. The three most widely-discussed options are the following:

- Estonia Connection: A new subsea pipeline to connect Estonian and Finnish natural gas grids.
- **Russia-Germany Connection:** A new subsea pipeline passing through the Baltic and running directly from Russia to Germany. A connection spur to be built to Finland.

• **Finland-Sweden Connection:** A new pipeline to connect Finland with Sweden. This pipeline could be connected with a proposed Norway-Sweden line, which would make it possible to bring Norwegian gas to Finland.

The second option has been studied and heavily promoted by interests in Russia. It is also one of the priority gas network projects in the EU's Trans-European Energy Networks scheme. The pipelines for the three options would require the co-ordination of a number of governments and major investment. While the options for such pipelines are being discussed, the plans do not yet have sufficient momentum to be considered viable in the short term. None of these projects has progressed far into the planning stage.

Liquefied natural gas (LNG) could provide another alternative natural gas supply possibility for Finland. While a degasification plant on Finland's southwestern coast could receive LNG ships sourced from anywhere in the world, there has not been very serious interest as yet in constructing such a plant. Gasum projects that the total cost of LNG would be 1.5 times that of gas supplied directly from Russia.

## CRITIQUE

The government's option to restrict the use of coal has been put aside now that development of the proposed nuclear plant has been approved. Allowing for market decisions on fuel use rather than strong government influence is a welcome development. At the same time, coal continues to be disadvantaged in heat generation owing to tax levels based on the carbon content of the fuel. While such a tax may be an effective tool in curbing GHG emissions from heat generation, care must be taken not to doubly disadvantage coal when the EU emissions allowance trading system is introduced. Such a system will make coal more expensive by requiring more allowances for each unit of electricity generated and reduce its role in the energy mix, which could have implications for energy security.

Peat, biomass and hydroelectricity are the few domestic fuels available to Finland. If one excludes nuclear as a domestic energy source, peat accounts for nearly 20% of domestically-sourced fuel, and 12% if nuclear is considered a domestic energy source. While imported energy sources are not necessarily less reliable than domestic sources, maintaining domestic energy production, and the production of peat in particular, contributes to a fuel diversity that clearly enhances Finland's energy security.

The government's treatment of peat incorporates a number of contradictory goals. As mentioned above, peat provides fuel diversity which enhances energy security. At the same time, peat has very high GHG emissions and it competes with other fuels such as forest chips whose development would be beneficial to Finland for energy security and environmental reasons. The tax

treatment of the fuel reflects these contradictions. Although peat has lower taxation than competing fuels based on its GHG emissions profile, it is sufficiently taxed to ensure that its price does not undermine the development of forest residue chips with which it competes. In this way, the government is trying to walk a thin line between too much and too little peat use and is thus effectively setting the amount of peat consumed in Finland. This approach is antithetical to the government's generally light-handed and successful approach to energy. Peat taxation could benefit from an elucidation of the competing objectives for peat and the resulting tax strategy. Such a clarification must consider that future taxation on fossil fuels, including peat, based on GHG emissions, will be highly dependent on the introduction of emissions trading based on the EU directive.

Peat's status in the total energy mix will also be very much affected by the counting methodology of GHG emissions from peat. According to the current Intergovernmental Panel on Climate Change (IPCC) methodology, peat produces substantial GHG emissions. Life-cycle analysis (LCA) suggests that peat emissions are lower than currently accounted for. Finland is proceeding with the LCA and intends to amend the IPCC methodology if necessary. This will present significant challenges because peat is neither widely used nor widely understood. Ireland, the only other OECD country using substantial amounts of peat is pursuing similar LCAs with the ultimate objective to amend the IPCC treatment of peat. If the LCAs conclude that peat emissions are lower than currently accounted for, Finland is encouraged to work with Ireland and thereby improve its chances to change the treatment of peat for GHG purposes.

The Finnish oil market works well. There is no evidence of market power despite Fortum's dominant position in the market, including the largest retail share and ownership of Finland's only two refineries. Prices are comparable to, or even slightly below, those of similar countries. The ability of all companies to import products as they wish is crucial to ensuring the market continues to perform well.

Regarding the natural gas market, the derogation, provided under the EU directive on the internal market is entirely logical for Finland. Nothing would be gained by opening the market to competition without the presence of viable alternative suppliers. The market as it stands, with Gasum as sole supplier, appears to function well. Prices are low and there are few customer complaints.

One area of possible concern about the current arrangement is the mode of regulation provided by EMA. While the light-handed nature of the *ex post* regulation works well in the electricity sector, the lack of established methodology in setting tariffs could be confusing in the gas sector. The *"ex ante* consultation" between Gasum and EMA helps to set guidelines, but a more clearly defined methodology would bring a welcome transparency to the tariffs and allow EMA and customers to exert pressure on Gasum to improve its efficiency.

The secondary gas market remains small and, given Gasum's monopoly, is unlikely to develop into a major force in Finland. Nevertheless, it does provide a means of lowering cost to the entire system by allowing private players to profit from selling unused capacity, thereby improving the system's overall efficiency. The secondary gas market also provides gas market players with an opportunity to gain experience with competition, which will be helpful if full competition in the sector arrives in Finland. It should therefore continue to be encouraged and will likely expand as more players become accustomed to it and realise ways in which they can gain profit or lower their gas costs.

Gas pipeline connection with other countries would be helpful to improve energy security and to introduce competition to Finland. However, such pipelines are very costly and Finland has had historical success with supplies from Russia. Pipeline development would have to be undertaken as part of a multi-country initiative that shares both costs and responsibilities. Finland is encouraged to continue to investigate such possibilities.

## RECOMMENDATIONS

The government of Finland should:

- Continue to value peat for its energy security advantages, while taking into account its costs and environmental implications.
- Continue the policy of non-interference in the oil markets, combined with effective anti-trust oversight.
- Explore the use of different methodologies to establish natural gas tariffs.
- Examine opportunities to expand the unregulated secondary gas market as a means of gaining more experience with competition in the sector and promoting, where possible, greater efficiency in gas use by customers.
- Continue to examine additional international gas connections, working with multi-country partnerships to find and develop economically feasible options that can increase security of supply and possibilities for competition.

# POLICY FRAMEWORK

In 1995, Finland introduced competition in electricity supply with the passage of the Electricity Market Act. The act required electricity grids to provide open access to their line and established an electricity regulator, the Electricity Market Authority, which became the Energy Market Authority (EMA) in August 2000. Access was initially available to consumers with demand above 500 kW, although this threshold was removed in 1997. Competition for household consumers did not begin until November 1998, when amendments to the act permitted small consumers to switch supplier without having to install a relatively expensive hourly meter, instead allowing load profiling to be used.

The reforms also stimulated industry restructuring. The main structural change was to create an independent transmission system operator (TSO). Fingrid, the Finnish TSO, is a fully independent company, created through a merger of assets between the publicly-owned IVO and privately-owned PVO.

The Electricity Market Act specifies that electricity generation, transmission, distribution and retail/trading have to be unbundled in accounts, although Fingrid is already independent. The Ministry of Trade and Industry (MTI) is planning to amend the Electricity Market Act so that network business will have a separate corporate identity.

In February 2003, amendments to the Electricity Market Act instituted changes to protect customers, set up a system of compensation to customers for outages and allow customers to change suppliers annually without a fee. The changes also implemented reciprocity conditions on parties wishing to import power from outside the Nordic system. The amendments were enforced on 1 September 2003.

## ECONOMIC REGULATION

EMA is responsible for regulating Finland's energy network and monitoring the retail sale of electricity. It carries out its price regulation *ex post*. Although network companies set their own network tariffs, they have an obligation to inform the regulator about any new tariffs. The regulator annually monitors each company's tariffs, taking into consideration their cost-reflectiveness and whether there is a reasonable rate of return.

EMA monitors network companies' profits by comparing reasonable returns on capital employed. It has completed studies on the relative efficiencies of the

distribution companies and has begun to introduce incentive regulation to allow bigger profits for companies with higher efficiency.

The network companies are obliged to report to EMA on income statements, balance sheets and other technical and financial figures. The regulator also has the right to request information from the network company it is investigating. The powers of the regulator to obtain this information were recently enlarged.

Companies can appeal against the regulator's decisions to the Supreme Administrative Court. In the meantime, all disputed decisions are suspended.

The Finnish Competition Authority and EMA supervise the market and investigate in the case of a firm abusing its dominant position. The Competition Authority also has an obligation to scrutinise mergers and has the power to block them or to attach conditions to their approval. Its rulings can be appealed to the Competition Council or to an administrative court.

The National Consumer Administration and the consumer ombudsman have also been active in monitoring the market and providing feedback to the government and regulator on the consumers' experience.

#### SUPPLY AND DEMAND

A large share of Finnish electricity demand comes from industry. The relatively high industrial consumption is explained by the importance of the pulp, paper and wood products sector, which accounts for approximately one-third of Finland's electricity consumption. Electricity consumption by the residential sector, which accounted for approximately one-quarter of all electricity consumption, is increased by the use of electricity for space heating. A total of about 620 000 homes, accounting for approximately 30% of Finnish residences, were heated with electricity. This degree of use of electricity for space heating, although much higher than the OECD average, is nevertheless lower than in neighbouring Sweden and Norway.

Peak demand for electricity, which has been growing steadily at around 3% per year in recent years, reached 13.9 GW in January 2003. Total capacity amounts to 14.8 GW and the Finnish electricity system depends on imports to meet peak electricity demands. However, total capacity will be scaled down as a result of the ongoing statistical revisions of hydropower and CHP capacity available during peak hours.

Finnish electricity comes from a highly diversified mix of fuels and technologies.



\* includes solar, wind, combustible renewables and wastes. Source: *Energy Balances of OECD Countries*, IEA/OECD Paris, 2003. In 2002, Finland's four nuclear power reactors supplied 27% of power generated, acting primarily as baseload providers. Coal-fired generation accounts for 21% of generation, mostly at both condensing and CHP plants. Hydropower, around 16% of the total, is also mainly centrally produced. Gas, mostly used in CHP plants, accounts for another 13%. The share of non-hydro renewables, principally biomass (including peat), of 10% of power supplied is approximately five times the IEA average of 2%.

Finland also possesses a relatively large proportion of decentralised generating capacity in the form of CHP systems. About 14 TWh of electricity is produced by industrial CHP and 12 TWh from district heating CHP systems. Most CHP systems are powered by peat/biomass combinations or natural gas, with a substantial contribution from coal. Finland's share of CHP is third behind Denmark and the Netherlands among IEA countries. The high share of CHP contributes to the relatively low share of transmission and distribution losses, at 3.6%, the lowest among IEA countries and well below the average of 6.8%.

#### INDUSTRY STRUCTURE

#### GENERATION

Fortum is the largest of Finland's several generating companies. It controls 5.3 GW of plant, representing about 40% of Finland's generating capacity. Fortum is 61% state-owned, with insurance companies as major private owners. In 2002, Fortum supplied about 26.2 TWh of electricity to Finnish end consumers.

The second-biggest generating company, the PVO group, is privately-owned. The majority of its shares is owned by Finnish industries and several municipal utilities. PVO controls about 3.3 GW of capacity and produces about 21 TWh of electricity.

A PVO subsidiary, Teollisuuden Voima Oy (TVO), operates two nuclear power plants and a coal plant. Fortum and two wood products companies and municipal utilities are minority shareholders in TVO. TVO produces electricity for its shareholders at cost. New projects are financed through investments of shareholder equity and loans. Electricity is supplied to the shareholders in accordance with the equity invested at a cost determined by the plants' operating and financing costs. The shareholders assume business risks with respect to cost overruns but in return receive electricity at cost price.

Most of the remaining electricity production is owned directly by industry or municipal companies. Much of this capacity is CHP.

One remarkable feature of the Finnish electricity system is industry's extensive direct ownership of power-generating equipment. Substantial power demand

at industrial sites, particularly in the forest products sector, appears to have been a factor motivating industry's involvement. This involvement has made the ownership structure of the electricity industry quite complex owing to extensive cross-ownership. The prominent role of Fortum and PVO in generation and ownership of transmission has caused concern among some market participants.

Generation investment is occurring in the Finnish market but currently at a relatively low rate. Much of the recent addition in capacity has been from CHP plants, using either natural gas or biofuels.

The next major increase in generating capacity planned in Finland is TVO's development of a fifth nuclear reactor. TVO is attracted by the relative economics of nuclear power compared to the cost of alternatives, particularly considering future environmental costs that might arise because of the Kyoto Protocol. This favourable economic assessment is supported by economic analysis carried out, which suggests that at a 5% real discount rate on invested capital costs, the nuclear plant is less costly than coal, natural gas or wind options. TVO has indicated that the 5% discount rate is appropriate for its investors, given their long-term outlook and the fact they will benefit as purchasers of the reliable low-cost electricity produced at the nuclear plant.



Source: Company annual reports.

#### TRANSMISSION

The Finnish Transmission System Operator (TSO) is Fingrid Oyj. It is owned by the State (12%), insurance companies (38%), Fortum Corporation (25%) and the PVO group (25%).

Fingrid is responsible for grid technical reliability, national power balance management and settlement, and the planning and expansion of the national grid. Fingrid is bound by law to offer non-discriminatory open access to all eligible customers wishing to use the system lines. Regulation of access is done *ex post*, meaning Fingrid is allowed to freely set its price and terms of access with regulatory review if a customer complains about the terms and pricing offered.

Fingrid charges generators €0.24 per MWh to access the grid and charges consumers/distributors taking power from the grid €3.75 per MWh during peak times (winter weekdays) and €0.75 per MWh at other times. Fingrid's charges are among the lowest in Europe. EMA is currently developing a proposed methodology for transmission pricing that would encourage more efficient use of the transmission system.

Finland is part of the Nordel system and relies on imports to meet peak demand. The interconnection from Russia is 1 400 MW. The import capacity from Sweden is 2 050 MW and the export capacity is 1 450 MW. The import capacity from Norway is 70 MW and export capacity is 100 MW.

Transmission investment is planned on a regional basis through Nordel. EMA must approve new lines within Finland, while MTI approves international transmission lines.

The current status of transmission capacity shows relatively limited transmission congestion inside Finland under normal conditions or between Finland and other countries. There are evidently constraints between Finland and Sweden during "wet" years. The current practice for congestion management in the Nordpool area is based on market-splitting. If the transmission demand between the two areas exceeds the physical capacity of the interconnector, the exchange will split the market into two areas and repeat the price calculation in the two areas separately. Power still flows from the high-price market to the low-price market (up to the maximum interconnection capability) and the net revenue gained from buying power in the low-price market and selling in the high price market is then shared between the Swedish and Finnish TSOs. The money is used to guarantee the soundness of the interconnection between the two countries and to lower the transmission grid tariffs. Such revenue resulting from international congestion also provides an investment signal to expand the international connections, although not necessarily an incentive since the TSOs gain revenue from such congestion. Under the Electricity Market Act, Fingrid has an obligation to develop its network, including the interconnections to neighbouring countries.

## DISTRIBUTION

At the beginning of 2003, there were 94 electricity distribution companies in Finland, five less than the previous year. When the Electricity Market Act came into force in 1995, there were 117 distribution companies, 141 in 1990 and more than 300 in the 1960s. The majority of these companies are municipally-owned. Many are now corporate entities, although some utilities, such as Helsinki Energia, remain part of the municipality and are therefore exempt from corporate tax. Most produce at least some of their own electricity. Fortum is the largest electricity distributor, responsible for about 15% of low-voltage distribution. Many foreign companies, including Vattenfall, E.On and Electricité de France, have purchased Finnish distributors.

#### **Distribution Costs**

The many utilities in Finland have a large dispersion of distribution costs. Figure 19 is a histogram of distribution charges of the 94 distribution utilities as of 1 March 2003.



Source: Energy Market Authority.

The histogram reveals that the difference between the lowest and highest charge is more than double. The strong variation in charges applies across customer classes.

An analysis of efficiencies of the utilities carried out in 2000 concluded that about one-fifth of the Finnish distributors could be considered efficient according to their controllable operating costs. EMA proposed an incentive methodology that would permit a company to keep larger profits if its efficiency exceeded a certain target and to lose profits if its efficiency was below this target. While EMA has allowed incentive bonuses for two companies that had high efficiency, it has yet to rule on any companies with low efficiency scores.

#### RETAIL SUPPLY AND LIBERALISATION OF CONSUMERS

There are approximately 80 retail electricity suppliers in the Finnish market. Fortum remains the single largest retail supplier of electricity with about 30% of the retail supply. Most of the remaining electricity is supplied by the retailing arm of the local distribution companies. Current law requires only accounting separation between the distributor and its retailing arm. However, in anticipation of the new EU electricity directive, there is a proposal to unbundle retail activities from distribution, provided the distributor has an annual distribution over 130 GWh (threshold approximate to 10 000 customers). The EU directive will require unbundling only for firms with 100 000 customers or more.

## WHOLESALE ELECTRIC POWER EXCHANGE

Finland is part of the Nordic Power Market (Nordpool), along with Sweden, Norway and Denmark. In this market, about 28% of power is traded through the Nordic voluntary power exchange spot market (Elspot). Finnish companies account for about 18% of the volume traded. Electricity market players can also trade electricity over the counter or through bilateral trade. Nordpool also has a longer-term financial market, the Eltermin market, where participants can make financial contracts for hedging or trading.

Elspot's trade volume has increased steadily from 4 TWh in 1998 up to 12 TWh per month, or close to 100 TWh per year, which is about a quarter of all generated electricity in the Nordic countries. Trading in the Nordpool financial markets is far higher, nearly 3 000 TWh in 2002, shared between the futures markets and bilateral market arrangements. Trading volumes fell in Eltermin in early 2003 compared to 2002 after several years of growth. Liquidity in the markets was diminished because of the tight power situation.

#### WHOLESALE PRICES

In the past few years, prices have begun to increase in the Nordic wholesale electricity market as demand catches up with supply. Consequently, even in a year of "average" rainfall, the Nordic area is beginning to become dependent on electricity imports.



The availability of hydropower in Norway and Sweden strongly affects wholesale electricity prices in Finland. Figure 21 shows the marginal cost of production in the Nordic electricity system. Prices in a given year are largely dictated by the production levels at hydropower facilities. Reduced hydroelectricity generation can require more thermal plants to come on line. This means that more expensive plants must be brought into service, thereby increasing the marginal cost of the system. More hydroelectricity generation means that only a few of the least expensive thermal plants are required with a resulting lower system marginal cost. In some very wet years, thermal generation is not needed for certain parts of the summer, causing the marginal cost of the system to fall to extremely low levels.



Source: ABB Financial Services.

Autumn 2002 was the driest in the Nordic region in the past 40 years. Figure 22 shows the dramatic increases in Finnish spot electricity prices and, for comparison, the prices in Oslo during winter 2002/2003. Note also the high degree of convergence between the two prices, with Finnish prices somewhat higher during periods of high rainfall in Norway (in 2000) and somewhat lower during the dry winter in 2002/2003.



Industrial and household electricity prices in Finland are lower than average in OECD countries when measured in simple exchange rate terms as shown in Figure 23.

Tariffs do not vary on the basis of location, but do vary by the voltage at which the customer receives electricity. The basic tariff structure is a two-part tariff where customers pay for capacity in kW and for energy in kWh. Commercial, educational and industrial tariffs also vary by season.

Retail electricity prices have fallen in Finland since market opening and continued to decrease until mid-2001. Following that time, prices gradually increased until the sudden increases in the winter of 2002/2003.

## "LIST" PRICES FOR RETAIL ELECTRICITY

If a retailer has a dominant market position within a certain area, the electricity vendor shall, according to section 22 of the Electricity Market Act, provide official retail or "list" prices for customers. These prices provide the basis for comparison between the price charged by the local retailer and the price charged by a competing retailer. The retailer may also offer a different price to consumers outside its service area.



Industry Sector



0.00 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.10 0.11 0.12 0.13

US\$/kWh

Note: Price excluding tax for Australia and the United States. Tax information not available for Korea. Data not available for Austria, Belgium, Canada, Germany, Luxembourg, the Netherlands, Norway, Spain and Sweden.



Note: Price excluding tax for the United States. Tax information not available for Korea. Data not available for Belgium, Canada, Germany, Spain and Sweden.

Source: Energy Prices and Taxes, IEA/OECD Paris, 2003.



Like the distribution charges, list prices for electric energy vary considerably by utility. Figure 25 shows the variation for consumers living in a detached house and consuming 5 MWh per year.

Two factors appear to explain this variation in list prices. First, many of the distribution companies have their own generating capacity, for instance for local district heating CHP plant, which they sell to local consumers at cost rather than at market prices. Second, for the municipal companies, these costs do not necessarily need to cover profit or tax.

The large variation in list prices should have encouraged more customers to switch suppliers. Furthermore, average list prices were higher than market prices until winter 2002/2003. However, the rate of switching suppliers was fairly low among smaller consumers, representing only 4% for household consumers. This was partly because of small suppliers concentrating on selling to their traditional customers and not accepting new customers outside their supply area. The cost of switching suppliers was also a deterrent. In addition, many customers favoured their local utility company who in turn lowered prices to match competitors.



Customers actively sought new suppliers during winter 2002/2003 when market prices rose. Customers who had switched suppliers requested to return to their local supplier at list prices. However, some retailers refused to take these clients back at list price, offering market prices instead.

One of the consequences of this experience is a change in legislation to allow consumers to switch suppliers annually without charge. This will lower barriers to switching among smaller consumers. The wide variation in energy as well as distribution charges in the market suggests that for now, consumers served by low-cost local retailers will have little incentive to switch supplier.

#### SECURITY OF SUPPLY

An analysis of Finland's security of electricity supply must consider its interconnections with Russia and the rest of the Nordic market. The major interconnection with Russia provides a significant amount of electricity available to Finland. The supply of this electricity to date has been reliable and has enhanced the security of electricity supply.

The security of supply of the Nordic market can best be assessed by considering the market as a whole. The driest half-year in 70 years led to a large reduction in available hydropower. In addition, the winter 2002/2003 was somewhat colder than average, putting pressure on demand. These events showed the ability of the Nordic electricity market to withstand the challenge of a winter with very low hydropower capability. Market mechanisms worked well, attracting imports of electricity and encouraging reduction in demand.

Growth in the electricity demand of the Nordic countries will continue to shift the region to increased reliance on electricity imports, even in normal years. Nordel's energy balance analysis for the region concludes that the entire region will still be able to cope with a single dry year out to 2006/2007 without serious difficulties through reliance on imports. However, a very dry year could cause difficulties that market mechanisms may not be able to make up.

As regards the winter peak demand for electricity, Finland is quite fortunate given that its peak occurs somewhat earlier in the day compared to the Nordel market as a whole. The Nordel forecast suggests that peak demand can also be met throughout the region in a normal winter. Meeting demand on an exceptionally cold winter day will require a very high reliance on imports into the Nordic region to balance the system.

Recognising the need for a harmonised solution to meet concerns about adequate supply, Nordel and the electricity group for the Nordic Council of Ministers organised a seminar in October 2002 to address this issue. A consensus emerged at the meeting on peak production capability and peak load in the Nordic electricity market wherein it was agreed that the long-term objective was to further develop the elasticity of demand in the marketplace. Simultaneously, transitional arrangements might be needed until this elasticity is adequately developed. It was important that these transitional arrangements and the legal frameworks for security of supply be harmonised. Studies are under way to identify opportunities to increase demand elasticity as well as the development of new financial instruments for hedging capacity shortages.

One of the initiatives proposed by the Finnish government was to develop a temporary system lasting only three years, for additional generating reserves, which would require the National Emergency Supply Agency to finance old condensing power plants to be used for security of supply purposes. The plants would be offered into the balancing market (Elbas) if a risk of a capacity shortage were perceived.

Energy producers strongly opposed this proposal because of their concern about the impact of the reserve capacity on the market price and on the signals for new investment in generating capacity. Finally, the amendment could not be agreed in advance of national elections and the proposal was shelved. However, a government working group is studying the security of supply issue, examining the role of supply and demand in balancing the market, and is expected to issue proposals in autumn 2003.

#### CRITIQUE

Finland's electricity market has developed quite well since the last in-depth review. It has a highly diversified supply of electricity, which includes a remarkably large share of biofuels and CHP. Investment in new baseload generating capacity has continued in Finland since the market opening and plans for the private sector to develop a new nuclear power plant are proceeding.

The wholesale market has also developed quite well as Finland has become more integrated into the Nordic market. Access to hydropower from Norway and Sweden helped reduce electricity prices from 1997 to 2002 and a shortage of hydropower in the winter of 2002/2003 led to price increases in Finland. The Nordic market has responded quite effectively to the shortage with significant demand reductions (mainly outside Finland) and greater imports into the Nordic region in response to higher electricity prices.

Electricity networks in Finland provide good quality service at reasonable cost. Transmission networks are relatively uncongested compared to the rest of the Nordic market and transmission and distribution losses are much lower than the OECD average.

Security of electricity supply by ensuring adequate peak generating capacity remains a key concern for the government. The government's proposals to finance old condensing power plants to ensure the availability of peak capacity was strongly resisted by industry, who was concerned by the precedent set by intervention in the market and its impact on the price signals needed to drive new private investment in generating capacity. The cost-effectiveness of demand-side measures (including distributed generation) needs to be more closely considered as part of any strategy to address peak load concerns.

Security of electricity supply in Finland can only be addressed optimally in the context of the Nordic market as a whole. The different timing of demand peaks, and the important role of hydropower in Sweden and Norway, suggest that greater interconnection of Finland with Sweden and Norway could enhance supply security.

Increased generating capacity in Finland may not only meet the relatively high demand growth but could also provide an export opportunity into Nordpool. Conversely, the availability of peaking capacity in Norway and Sweden could enhance supply security in Finland.

For market participants to be able to take advantage of these opportunities, greater transmission interconnection between Finland and Sweden, and between Sweden and Norway, would be needed. Although a sound planning process already exists in Nordel, a co-ordinated approach to the financing of new transmission investment and more generally to the operation of the Nordic market is also necessary.

While the wholesale market is developing well, and larger power consumers have been successful in negotiating rate reductions, relatively few small customers have changed supplier. New measures passed by the government to eliminate switching fees (if the customer had not changed its supplier in the past year) should help. However, the fundamental problem has been a lack of retailer interest in acquiring customers individually, owing to factors such as supplier of last resort obligations and local utility pricing policies.

Finnish network companies' costs and quality of service appear to be quite good despite a lack of incentives to encourage efficiency through regulation. The regulatory approach is *ex post* and is primarily based on profit regulation. Decisions on many pricing issues, such as the treatment of transmission congestion fees or locational pricing, are the responsibility of Fingrid rather than an independent party. Unbundling requirements at the distribution level are currently not very strong. Expenditures on regulation are exceptionally low, less than 0.1% of sector turnover despite annual *ex post* control.

There is scope to improve regulatory practice. A more active role for *ex ante* regulation, in co-operation with other Nordic regulatory bodies, could guide a more sophisticated approach on transmission pricing and the allocation of congestion rents. Stronger separation requirements between distribution and retail could activate more competition for retail consumers. Greater use of incentive regulation over longer test periods could encourage distributors to innovate and reduce costs.

The final question is whether concentration of ownership of power generation in the Finnish market is of concern. Studies of Finnish electricity market behaviour have failed to uncover any instance of excessive pricing. However, the Nordic power market is likely to tighten in the coming years as a consequence of continued demand growth. Increased transmission congestion on interconnections is possible, and may provide greater opportunities for manipulation. Oversight of the Finnish and Nordic electricity markets, and resources to detect manipulation, are quite limited. Greater surveillance and closer co-operation between Nordic competition authorities would be a deterrent to such behaviour. Expanding interconnection capacity between Finland and the rest of the Nordic market would further reduce such concerns.

## RECOMMENDATIONS

The government of Finland should:

- Make greater efforts to harmonise rules in the Nordic electricity market, particularly common approaches to enhancing security of supply and market oversight.
- In order to ensure more efficient development of transmission infrastructure, adopt a common Nordic approach to mechanisms for financing transmission investment.
- Make greater use of ex ante regulation, particularly to encourage more efficient pricing of transmission and the disposition of transmission congestion rents.
- Proceed with the legal separation of distribution from retailing. Evaluate the minimum size of companies to be separated.
- Examine further measures to increase customer choice, including supplier of last resort policies.

#### **CURRENT NUCLEAR GENERATION**

In 2001, nuclear power accounted for 18% of Finland's TPES and 31% of its electricity generation. Finland has two nuclear power plants; Loviisa and Olkiluoto. Loviisa consists of two pressurised-water reactors (PWRs) with a total capacity of 970 MWe and is owned and operated by Fortum. Olkiluoto consists of two boiling-water reactors (BWRs) with a total capacity of 1 680 MWe and is owned and operated by Teollisuuden Voima Oy (TVO). Loviisa is licensed for operation up to 2007 and Olkiluoto up to 2018. The estimated technical lifetimes of the plants extend beyond their licensing. Since beginning commercial operation, in 1977-1981 for Loviisa and 1979-1982 for Olkiluoto, the plants have been refurbished and their capacities increased by 9% and 27%, respectively.

The technical and safety performance of both plants has been excellent. Their average annual availability factors are among the best in the world, with levels consistently close to or above 90%. By the end of the last century, the Finnish nuclear power plants enabled GHG emissions from the Finnish energy sector to be lowered by some 20 Mt  $CO_2$  or 30% by year<sup>10</sup>.

#### PROPOSED NEW NUCLEAR PLANT

In May 2002 the Parliament ratified the government's favourable decision-inprinciple on the construction of a fifth nuclear power reactor. This project is being developed by TVO. Following active debate of the issue on both sides, the Parliament approved the government's decision by a vote of 107 to 92. This approval implies neither explicit state guarantees for the plant's success nor an explicit endorsement of the project. Parliamentarians supporting the new plant considered that within the framework of the NCS and the Kyoto Protocol, additional nuclear power would be the most cost-effective option for generating baseload power and, as such, was "in line with the overall good of society". This approval also required the consent of the local authorities where the plant would be built.

An economic assessment carried out by the Lappeenranta University of Technology<sup>11</sup> concluded that nuclear power is the cheapest option when levelised generation costs are calculated in the Finnish context. Assuming a

<sup>10.</sup> This result assumes that nuclear power will be replaced by coal-fired condensing power plants.

<sup>11. &</sup>quot;Comparison of Electricity Generation Costs in Finland", April 2001.

40-year economic lifetime and a 90% availability factor (7 884 operating hours), nuclear power remains competitive for real interest rates ranging between 5% and 10%. Table 9 shows electricity generation costs as calculated in the report. The costs assume a 1 250 MWe nuclear unit with an investment cost of around €1 900 per kWe.

Table ᠑ Electricity Generation Costs at 5% Real Interest Rate (2001 € cent per kWh)						
Capital costs	13.8	7.6	5.3	10.2	13.0	40.1
O&M	7.3	7.4	1.5	6.5	8.2	10.0
Fuel	3.0	17.1	23.7	15.8	18.4	-
Total	24.1	32.1	30.5	32.5	39.6	50.1

\* Calculated without investment grant and tax rebate.

\*\* Calculated without investment grant and tax rebate for 2 200 operation hours.

Source: "Comparison of Electricity Generation Costs in Finland" (2001); Lappeenranta University of Technology, Finland.

The proposed plant would be a commercial enterprise owned by TVO. TVO is an energy company owned 57% by companies that are majority-owned by private concerns and 43% by companies that are majority-owned by the government and municipalities. The largest shareholder is Pohjolan Voima Oy (PVO), a co-operative controlled mostly by energy-consuming companies and municipalities. The second-largest shareholder is Fortum Power and Heat Oy, owner of numerous power plants and 61% owned by the Finnish government. TVO has a co-operative structure in that it supplies electricity directly to its shareholders at cost.

The fifth nuclear reactor will be an evolutionary, large-size light-water reactor (LWR). The capacity of the plant will range between 1 GWe and 1.6 GWe, with an estimated cost of between  $\in$  1.7 and  $\in$  2.5 billion. It will be constructed on the site of an existing plant, such as Loviisa or Olkiluoto, which are both adequate, from a safety and environmental viewpoint, to accommodate such a unit. Consultation with local population has been positive in both cases.

Manufacturers' bids were received in early spring 2003 and, according to TVO, the choice of the design and manufacturer will be made before the end of 2003. TVO projects that the construction licence and other permits will be obtained by 2005 and that construction will take place from 2005 to 2009. TVO estimates that the plant can come on line in 2009.

The nuclear construction industry is preparing for the construction and TVO plans to have a dedicated team of approximately 100 staff in place for this purpose during 2003. The safety authority has already carried out a pre-review of some designs likely to enter the competition and assessed whether they fulfil the requirements of the Finnish safety regulation.

## FUEL CYCLE AND WASTE MANAGEMENT

Finland has no front end fuel cycle industry, relying on imports for all nuclear fuel supply. The excess production capacities around the world make the international market favourable to buyers. Security of supply is guaranteed by diversity of import sources and fuel inventories at the power plants. Low-and intermediate-level radioactive wastes from routine operation at the Loviisa and Olkiluoto plants are disposed of in repositories that were commissioned in 1992 and 1997, respectively.

For the back end of the fuel cycle, Finland has chosen direct disposal of spent fuel. Technically, the disposal of spent fuel is the responsibility of Posiva Oy, a subsidiary of TVO (60%) and Fortum (40%). In May 2002, the Parliament ratified the government's favourable decision-in-principle authorising Posiva Oy to pursue the implementation of a final repository for spent fuel near Olkiluoto. The disposal facility will be located in the granite bedrock formation at a depth of some 500 metres. Technical, environmental and safety studies will be pursued on the site by Posiva Oy in the coming decade. The commissioning of the repository is scheduled for 2020. The size of the repository will be adequate to dispose of the spent fuel arising during the entire technical lifetime of the existing Finnish nuclear units and of the planned fifth unit (see below).

According to Finnish law, nuclear power companies are responsible for the management and disposal of radioactive waste arising from their plants. The costs of waste management are included in the price paid for nuclear electricity and the money collected is accumulated in the National Nuclear Waste Management Fund, which is administered by MTI. MTI collects money from nuclear producers to ensure that adequate funds are available to provide the necessary short-, medium- and long-term treatment of nuclear waste. As of year-end 2002, the fund had a balance of €1 281 million. This amount covers all anticipated future financial liabilities corresponding to high-level waste disposal and plant decommissioning.

## LEGAL FRAMEWORK AND NUCLEAR SAFETY

Nuclear energy activities in Finland are principally governed by the 1972 Nuclear Liability Act, the 1987 Nuclear Energy Act and the 1991 Radiation Protection Act. The Nuclear Energy Act states that permission to construct a nuclear power plant with more than 50 MWe capacity requires the decisionin-principle from the highest level of government and of the Parliament. The Act on Environmental Impact Assessment (EIA) of 1994 stipulates that an EIA is compulsory for any nuclear facility. The 1972 Nuclear Liability Act, as amended, implements Finland's obligations under the international conventions on Third Party Liability (Paris and Brussels) to which Finland is a party.

The Radiation and Nuclear Safety Authority (STUK) is responsible for nuclear safety. STUK is an independent state-funded body; it reports to the Ministry of Social Affairs and Health, and MTI. STUK's responsibilities include the regulation of nuclear safety (including prevention of harmful effects of radiation, safe use of nuclear energy and radiation, research on radiation protection, training and information), physical protection, safeguards and emergency planning in the nuclear context.

STUK is involved in licensing procedures for building and operating nuclear power plants and also reviews the safety of plants and assesses the compliance of nuclear facilities with the safety requirements of Finnish law. During plant operation, STUK inspects, reviews and assesses the adequacy of safety levels. STUK reviews the construction permit for a new nuclear unit and ensures that it complies with all relevant safety regulations.

## CRITIQUE

The construction of a fifth nuclear unit is a major project and a key element in meeting increased Finnish electricity demand and addressing global climate change. Despite an ambitious timetable, it seems feasible to achieve commercial operation by the end of 2009 as planned, given the preparedness of both industry and STUK, and the authorisations already obtained from the central government and local authorities. Nevertheless, the government should monitor the plant's progress so that the licensing process for the new plant is completed within the current regulatory framework without unnecessary delay. It should also monitor the plant's progress to be aware of any difficulties in financing or construction that could delay the plant's scheduled commercial operation. The government should be prepared to implement alternative options to meet electricity demand and reduce GHG emissions, if necessary. At the same time, the government should not favour this project over other projects, despite the substantial (indirect) state ownership in TVO. Finland has a successful liberalised electricity market in which independent players take investment decisions, and nuclear facilities should not be an exception.

Security of energy supply, climate change mitigation and economics were important factors in the decision of the government and Parliament to allow the plant development to proceed. The economic advantages of nuclear power in the present Finnish context are stability of costs in the long term (as compared with potential volatility of gas prices, for example) and projected lower levelised lifetime costs. TVO's structure as a co-operative energy company reduces investor risks, since the owners will also be the main consumers of the proposed plant's output. This ownership structure will also give TVO access to relatively low interest rates, thus reducing the plant's overall cost.

The government and industry have taken timely measures towards the implementation of safe solutions for the management and disposal of all types of radioactive waste. The high-level waste repository near Olkiluoto is scheduled to be commissioned by 2020. However, a number of laboratory tests remain to be completed before obtaining the construction and operating licences, and the industrial production of the storage casks is not yet in place. The completion of the repository is essential for the future of Finland's nuclear energy and the government should continue to monitor effectively the implementation process.

Finland is currently reconsidering its third-party liability policy and is considering moving to an unlimited liability for the nuclear operator in case of a severe nuclear accident. This is going beyond the target of the international conventions and could increase the financial risk to investors in nuclear power plants.

## RECOMMENDATIONS

The government of Finland should:

- Ensure that the licensing process for the new plant is completed without unnecessary delay within the current regulatory framework.
- Pursue active regulatory support for the implementation of the high-level waste repository.

## OVERALL POLICY STRUCTURE AND OBJECTIVES

Energy technology development is a key activity in Finland's national energy policy. The government sees advanced technology as an important tool in curbing energy use and energy-related emissions. The objective of the energy technology research and development (R&D) is to develop efficient and environmentally sound solutions that are competitive in the international market. Energy technology research is linked to long-term national policies on industry, energy and technology. Energy technology exports have substantially increased during the last ten years. From an export level of approximately €800 million in 1991, energy technology exports rose to €3 200 million in 2000. Energy technology now accounts for 6% to 7% of all Finnish exports.

The government contributes to the development of new technology for energy generation and use. Priority is given to technologies that suit Finland's particular characteristics, such as energy conservation and bioenergy. More than 3% of Finland's gross national product (GNP) is allocated to research and development. This is among the highest percentage among industrialised countries. Government spending on energy research, development and demonstration in 2001 totalled €62.6 million. Figure 26 shows government energy technology R&D spending from 1990 to 2001 for the major technology categories.

The government's support for technological R&D work is channelled through the National Technology Agency (Tekes), which operates under MTI. Tekes finances and organises research programmes to develop industrial products and production methods, research at institutes and universities and joint technology projects run by companies and research institutes. This funding covers basic R&D activities through the first full-scale applications (demonstrations) of new technologies.

Other funding organisations are the Academy of Finland and the Finnish National Fund for Research and Development (Sitra). The Academy funds basic research on energy production and, in particular, the training of researchers in this field. Sitra is a public fund that allocates 70% of its resources to joint ventures and the promotion of technology transfer.

The national public research institute, the Technical Research Centre of Finland (VTT), is responsible for the implementation of a number of the national energy technology research programmes. VTT carries out its own technology research and testing as well as work commissioned by companies.



Government Energy R&D Spending, 1990 to 2001

#### Sources: OECD Economic Outlook, OECD Paris, 2003 and country submission.

#### MAJOR RESEARCH PROGRAMMES

Finnish energy R&D is organised into national research programmes that coordinate all relevant parties, including industrial companies, research institutes and universities. Energy technology developers form a tightly integrated entity – an energy cluster. The research programmes aim to enhance research activities and to bundle individual projects together into larger research packages. Companies play an important role in the applied research projects. Finnish enterprises are well represented in the executive committees of these research programmes. Some of the applied research is carried out as concerted projects, for which more than 50% of the financing is granted by the companies. Technological results from any R&D efforts receiving public funds belong to the public domain.

The first, broad package of eleven energy research programmes was established in 1993 and ran until 1998. The programmes were established by Tekes on the policy level and were carried out by VTT on the research level. The total funding for these programmes was €250 million, about half of which came from government funds, with the participating companies providing a significant portion of the remainder. Most of the programmes active now were started in 1999. New programmes are being planned and implemented continuously as the need arises. Energy technology programmes active in 2002 are the following:

- Engine Technology Programme (ProMOTOR), 1999 to 2003.
- Energy and the Environment in Transportation (MOBILE 2), 1999 to 2003.
- Fission Nuclear Safety and Waste Research Programmes (FINNUS), 1999 to 2002 and (KYT), 2002 to 2005.
- Fusion Energy Research Programme (FFUSION 2), 1999 to 2002.
- Information Technology and Electric Power Systems Technology Programme (TESLA), 1998 to 2002.
- Modelling Tools for Combustion Process Development (CODE), 1999 to 2002.
- Process Integration Technology Programme, 2000 to 2004.
- Technology and Climate Change Programme (CLIMTECH), 1999 to 2002.
- Wood Energy, 1999 to 2003.
- Small-Scale Wood Energy, 2002 to 2004.
- Recycling Technologies and Waste Management (STREAMS), 2001 to 2004.
- Fine Particles Technologies, Environment and Health (FINE), 2002 to 2005.

The total budget for these programmes is estimated to be about  $\in$  210 million, about half of which is provided by Tekes.

VTT has also launched energy technology programmes with the aim of pooling its wide resources and has thus enhanced internal synergies. The technology programmes are strategic research entities formed to develop industry-specific technologies and to serve industry. Five programmes connected to energy technology were in place in 2002. New programmes are continuously being projected and are launched according to industrial needs and interest. Prior to initiating a programme, discussion of the contents and objectives is carried out with potential industrial participants.

Finland participates in 20 IEA Implementing Agreements. It also participates in the multilateral research co-operation on energy technology between the five Nordic countries and has concluded special bilateral agreements on technological research with Japan and the US.

## ENERGY RESEARCH AREAS

## ENERGY EFFICIENCY AND FUEL USE

RD&D is a key tool for improving energy efficiency under the national energy and climate change policies. Sustainable development issues, where climate change is a focal point, are now featured more strongly in Tekes's strategy. Technological RD&D on energy efficiency is almost always integrated into other technological sectors. In Finland the main sectors for energy efficiency RD&D are the forestry industry, metal industry, buildings and residential sector as well as transportation. Tekes implements energy efficiency RD&D as a horizontal activity, which covers all technological branches. Approximately 40% of governmental expenditures for energy RD&D are allocated to energy efficiency or energy conservation technologies.

From 1997 to 2001, MTI carried out a Research Programme on Energy Conservation Decisions and Behaviour (LINKKI 2). This programme focused on the relationships between energy conservation and the users of technology, either as consumers or in other roles. The total budget of the LINKKI 2 programme was  $\in 0.7$  million.

## COAL, OIL AND GAS

Finland has no coal, oil or gas resources and all these fuels are imported. No specific research programmes exist in these areas. However, general research activities, such as process technology and co-combustion technologies with biomass indirectly concern these fuels. Finland has two oil refineries, both owned by Fortum Corporation. Fortum has R&D activities on refining technologies and in particular on environment-friendly oil products.

#### PEAT

Finland regards peat as a slowly renewable biomass fuel. In this way, it is distinguished from "biomass" such as wood and from "fossil fuels" such as coal. In co-ordination with MTI, the Ministry of Agriculture and Forestry and the Ministry of the Environment have started a peat research programme entitled "Greenhouse impacts of the use of peat and peatlands in Finland". The programme aims to develop models for the GHG dynamics (dynamic emission factors) of the peatland using forms of peat harvesting and combustion that are relevant for LCA (life-cycle analysis). The programme will run four years and its total budget for the period 2002 to 2005 is approximately €1.5 million.

#### RENEWABLE ENERGY

Bioenergy technology development is given high priority within overall energy RD&D work. Public funds currently granted for bioenergy R&D projects and bioenergy demonstrations annually amount to €7 million each. The R&D financing is principally channelled through the Wood Energy and Small-Scale Wood Energy technology programmes by Tekes. The Wood Energy programme's

main objective is to create techno-economic preconditions for increasing the use of forest residue chips in Finland fivefold by the year 2003. A parallel target is to improve the quality of wood fuels. The Wood Energy programme's budget for the period 1999 to 2003 is  $\in$  35 million, of which Tekes finances about  $\in$ 11.5 million. The programme involves international co-operation such as the ALTENER programme and the IEA Bioenergy Agreement. The total budget of the Small-Scale Wood Energy programme is  $\in$ 5 million, of which Tekes finances  $\in$ 3 million.

In biomass technologies, efforts will focus on the development of the so-called fuel supply chain, which includes fuel processing and combustion. A rapid increase in the use of forest residue chips requires big consumption sites and large-scale procurement operations integrated into the production of industrial raw wood, whilst maintaining an environmentally sound production of forest residue chips and sustainable forest management.

Concepts are also being developed for space heating using renewable energy sources. The targets for development include integration with other energy sources and building technology solutions, improvement of efficiency and reduction of emissions from biofuels. The FINE programme includes combustion process developments to reduce fine-particle emissions from biofuels in addition to dealing with other environmental and health issues. Within the development of bioenergy technologies, various solutions are now ready to be introduced into the domestic as well as international markets.

New energy technologies for waste-to-energy projects were developed in the Waste to REF & Energy Technology programme 1998-2001. This work is partially continued in the new Recycling Technologies and Waste Management (STREAMS) programme 2001-2004. The STREAMS programme includes recycled and recovered fuels research in addition to other materials recovery and recycling research. The total budget for the 2001 to 2004 period is approximately €27 million.

From 1993 to 1998, Tekes carried out a technology programme for wind and solar energy (NEMO, Advanced Energy Systems and Technologies). Funding of the wind and solar energy R&D projects and demonstrations continues, despite no new technology programme being initiated after the termination of the NEMO programme. It is important for wind power to achieve high reliability, particularly given Finland's difficult climatic conditions. Raising the unit size and a shift towards offshore plants are future technological challenges that Finland must address before fully benefiting from wind technology. New market niches are sought for solar power applications, and development of system and cell technologies continues. The potential for passive solar energy is also being studied. Hydropower plants aim to reduce investment costs in small-sized classes and to minimise their environmental impact.

In the National Climate Strategy, the government considered the need for a new instrument for large-scale demonstration projects, which represents an investment aid in the order of  $\leq 20$  to  $\leq 30$  million every three years granted to one or two new, not yet demonstrated renewable energy technologies. MTI aims to receive funds for the new demonstration aid in 2003.

## HYDROGEN TECHNOLOGY AND FUEL CELLS

Interest in hydrogen technology and fuel cell R&D has grown steadily in Finland. The development work in this area currently focuses on low-temperature cells (Alkaline, PEM) and high-temperature cells (SOFC). The principal objective is to find and develop new applications for fuel cells as part of Finnish energy technology products. Annual public funding in this area has totalled approximately  $\leq 1$  to  $\leq 2$  million.

# ELECTRICITY SYSTEM AND GRID INTERCONNECTION TECHNOLOGIES

The TESLA programme provides Finnish players in the electricity market with a means of improving network management and use, for managing electricity procurement and sales, and for making more effective use of energy. The estimated total cost of the programme is  $\notin$  22 million, of which Tekes will provide almost  $\notin$  10 million. The programme includes confidential product development projects carried out by companies and research-based joint projects taking place at research institutes and companies. The TESLA programme focuses on distribution network automation, management of industrial electrical systems, information systems for electricity trading and risk management, IT solutions, terminals and control systems for communication between power companies and electricity users, and applications of new telecommunication technologies in electricity distribution.

A new programme, which would focus on the opportunities of and barriers to the distributed energy systems, is planned to start in 2003.

## NUCLEAR FISSION R&D

Most of the nuclear fission energy R&D is conducted by industry. The nuclear power companies bear the costs of R&D in specific applied research in nuclear safety. Although there are no state funds earmarked for nuclear fission energy R&D, MTI can fund energy R&D and in particular basic research on nuclear safety and waste management.

Finland has no research centre dedicated to nuclear energy. However, nuclear energy research is carried out in several institutes, in particular the Technical
Research Centre of Finland (VTT) and universities of technology, such as Helsinki and Lappeenranta. The Radiation and Nuclear Safety Authority (STUK) and the nuclear power companies, Fortum and TVO, carry out research directly and finance research in institutes and universities.

Tekes contributes seed funding to industrial R&D projects, including those in the nuclear sector and is responsible for public nuclear fusion research funding. The total annual volume of Finnish research on nuclear energy, including around 25 person-years for fusion, is estimated at 200 person-years, with a total funding of nearly €30 million per year.

## CRITIQUE

Finland has developed an impressive energy R&D programme, which succeeds on a number of levels. The level of government funding is above that of most other countries if measured as a share of GDP. This allows the development and advancement of technologies that would not otherwise be supported by the private sector owing to their longer-term time horizons or the inability to secure technology patent protection. The government has instituted an impressive level of co-operation in R&D ventures, such as the co-operation between government and academia and with and between private companies. Finland also co-operates actively on an international level, as demonstrated through its participation in 20 IEA Implementing Agreements. Such cooperation increases the chances for successful R&D, while reducing the costs to individual parties.

Finland wisely concentrates its resources on areas that strategically suit its energy characteristics. As a result, bioenergy, nuclear fission and energy conservation receive disproportionate amounts of funding. In 2001, these three energy research areas received 60% of the government's R&D budget. These areas can also assist Finland in curbing its  $CO_2$  emissions as a means of meeting the Kyoto Protocol targets at lesser cost. Finland's R&D spending appears to have helped its industry and now the manufacture and export of Finnish energy technologies play an important role in the country's economy.

One area that could possibly be improved might be the monitoring of results. The 300% increase in Finnish R&D export is an impressive outcome. However, it is unclear to what extent the government R&D programmes have contributed to the energy policy objectives, such as security of supply and climate change mitigation. In this regard, development of an indicator or a set of indicators to assess the effectiveness of government-funded R&D efforts merits consideration. The ability to trace government R&D in basic or more advanced research directly to the manufacture of energy technologies (used domestically or exported) would allow Tekes and MTI to better evaluate through programmes and if necessary seek to improve them.

# RECOMMENDATIONS

The government of Finland should:

- Develop an indicator or set of indicators that manages to better assess the effectiveness of government-funded energy research and development efforts.
- Monitor and support the industry R&D effort to ensure that the existing and future nuclear power plants continue to improve their technical and safety performances and that radioactive waste is managed and disposed of safely.

# ANNEX

## ENERGY BALANCES AND KEY STATISTICAL DATA

							U	nit: Mtoe
SUPPLY								
		1973	1990	2000	2001	2010	2020	2030
TOTAL PRODUCTION		4.9	12.1	15.1	15.2	19.2	19.8	
Peat Oil		0.1	- 1.8 -	1.2 0.1	- 1.4 0.1	1.9 -	2.0	  
Comb. Rene Nuclear	ewables & Wastes <sup>2</sup>	3.9	4.3 5.0	6.7 5.9	6.6 5.9	7.8 8.4 1.1	8.4 8.2	  
Geothermal Solar/Wind	/Other <sup>3</sup>	-	-	0.0	0.0	0.0	0.1	
TOTAL NET	IMPORTS <sup>4</sup>	16.6	17.7	18.1	18.6	18.4	20.4	
Peat	Exports Imports Net Imports Exports	0.0 2.4 2.4 -	0.0 4.4 4.4 -	3.6 3.6 0.0	4.2 4.2 0.0	4.3 4.3 -	5.7 5.7 -	  
Oil	Net Imports Exports Imports Bunkers Net Imports	0.2 14.0 0.1 13.8	- 1.7 12.5 0.6 10.2	-0.0 5.2 16.0 0.7 10.1	-0.0 5.0 15.4 0.6 9.8	- 9.2 9.2	- 9.4 - 9.4	   
Gas Electricity	Exports Imports Net Imports Exports Imports Net Imports	0.0	2.2 2.2 0.0 0.9 0.9	3.4 3.4 0.0 1.1 1.0	3.7 3.7 0.2 1.0 0.9	4.4 4.4 0.0 0.5 0.5	4.9 4.9 0.0 0.5 0.5	   
TOTAL STO	CK CHANGES	-0.1	-0.6	-0.2	0.1	_	-	
TOTAL SUP Coal <sup>1</sup> Peat Oil Gas Comb. Rene Nuclear Hydro Geothermal Solar/Wind Electricity Tu	PLY (TPES) ewables & Wastes <sup>2</sup> ⁄Other <sup>3</sup> rade <sup>5</sup>	<b>21.3</b> 2.5 0.0 13.6	<b>29.2</b> 4.1 10.3 2.2 4.6 5.0 0.9 - 0.9	<b>33.0</b> 3.6 1.4 9.6 3.4 6.7 5.9 1.3 - 0.0 1.0	<b>33.8</b> 4.2 1.9 9.4 3.7 6.6 5.9 1.1 - 0.0 0.9	<b>37.6</b> 4.3 1.9 9.2 4.4 7.8 8.4 1.1 - 0.0 0.5	<b>40.2</b> 5.7 2.0 9.4 4.9 8.4 8.2 1.1 0.1 0.5	
Shares (%) Coal Peat Oil Gas Comb. Rene Nuclear Hydro Geothermal	wables & Wastes	11.8 0.2 63.6 18.5 4.2	14.1 4.2 35.1 7.5 15.6 17.2 3.2	11.0 4.4 29.2 10.4 20.4 17.8 3.8	12.4 5.7 27.9 11.0 19.7 17.6 3.4	11.5 5.1 24.5 11.8 20.7 22.3 3.0	14.1 5.0 23.4 12.1 20.9 20.4 2.8	
Solar/Wind/Other Electricity Trade		1.7	- 3.1	3.1	2.5	0.1 1.2	0.1 1.2	

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

## DEMAND

## FINAL CONSUMPTION BY SECTOR

	1973	1990	2000	2001	2010	2020	2030
TFC Coal <sup>1</sup> Peat Oil Gas Comb. Renewables & Wastes <sup>2</sup> Geothermal	<b>19.4</b> 1.0 0.0 11.5 0.0 3.9	<b>22.7</b> 1.2 0.4 9.7 1.0 3.5	<b>24.8</b> 0.8 0.3 8.3 1.0 5.0	<b>25.2</b> 0.8 0.3 8.5 1.1 4.8	<b>29.2</b> 2.0 0.4 8.7 1.9 5.8	<b>31.3</b> 2.3 0.4 8.9 2.0 6.2	
Solar/Wind/Other Electricity Heat	2.3 0.6	- 5.1 1.9	- 6.5 2.8	- 6.6 3.0	- 7.7 2.7	- 8.5 2.9	  
Shares (%) Coal Peat Oil Gas Comb. Renewables & Wastes Geothermal	5.3 0.1 59.2 0.1 20.3	5.1 1.8 42.5 4.3 15.5	3.4 1.3 33.7 4.0 20.2	3.3 1.3 33.7 4.2 19.2	6.8 1.4 29.7 6.6 19.8	7.4 1.4 28.4 6.4 19.9	   
Solar/Wind/Other Electricity Heat	11.9 3.1	22.3 8.4	- 26.2 11.2	26.3 12.0	26.4 9.3	- 27.3 9.2	 
TOTAL INDUSTRY <sup>6</sup> Coal <sup>1</sup> Peat Oil Gas Comb. Renewables & Wastes <sup>2</sup> Geothermal	<b>7.6</b> 0.9 0.0 5.0 0.0	<b>10.5</b> 1.2 0.4 2.6 0.9 2.5	<b>12.2</b> 0.8 0.3 1.8 0.9 3.9	<b>11.9</b> 0.8 0.3 1.7 1.0 3.7	<b>15.1</b> 2.0 0.4 1.7 1.9 4.6	<b>16.5</b> 2.3 0.4 1.8 1.9 5.0	
Solar/Wind/Other Electricity Heat	1.6 0.1	2.8 0.2	3.7 0.7	3.6 0.8	4.4 0.2	4.9 0.2	 
Shares (%) Coal Peat Oil Gas Comb. Renewables & Wastes Geothermal	12.1 0.2 66.2 0.1	11.0 3.6 24.7 9.0 23.4	6.8 2.4 15.0 7.6 32.1	6.9 2.5 14.5 8.1 30.8	13.1 2.6 11.2 12.3 30.3	13.9 2.4 11.0 11.6 30.0	    
Solar/Wind/Other Electricity Heat	20.4 1.0	26.6 1.7	30.1 6.0	30.6 6.5	29.1 1.5	29.7 1.4	 
TRANSPORT <sup>7</sup>	2.6	4.4	4.5	4.6	4.4	4.7	
TOTAL OTHER SECTORS <sup>8</sup> Coal <sup>1</sup> Peat Oil Gas Comb. Renewables & Wastes <sup>2</sup> Geothermal	<b>9.3</b> 0.1 0.0 3.9 0.0 3.9	<b>7.9</b> 0.0 0.0 2.7 0.0 1.1	<b>8.1</b> 0.0 0.0 2.1 0.1 1.1	<b>8.7</b> 0.0 0.0 2.2 0.1 1.2	<b>9.7</b> 0.0 0.0 2.6 0.1 1.2	<b>10.1</b> 0.0 0.0 2.5 0.1 1.3	  
Solar/Wind/Other Electricity Heat	0.8 0.5	2.2 1.7	2.8 2.0	3.0 2.3	3.3 2.5	3.6 2.7	 
Shares (%) Coal Peat Oil Gas Comb. Renewables & Wastes Geothermal	1.1 0.1 42.3 42.6	0.1 0.2 35.0 0.5 13.6	0.3 25.6 0.8 13.5	0.3 25.7 0.8 13.4	0.2 27.3 0.6 12.3	0.3 24.5 0.7 12.6	
Solar/Wind/Other Electricity Heat	8.2 5.7	- 28.5 22.1	34.4 25.4	- 34.0 26.0	33.9 25.6	35.5 26.4	 

#### Unit: Mtoe

## DEMAND

ENERGY TRANSFORMATION AND LOSSES	

ENERGY TRANSFORMATION AND	D LOSSES						
	1973	1990	2000	2001	2010	2020	2030
ELECTRICITY GENERATION <sup>9</sup> INPUT (Mtoe) OUTPUT (Mtoe) (TWh gross)	<b>3.5</b> <b>2.2</b> 26.1	<b>11.9</b> <b>4.7</b> 54.4	<b>14.8</b> <b>6.0</b> 70.0	<b>16.1</b> <b>6.4</b> 74.5	<b>17.6</b> <b>7.5</b> 87.6	<b>19.0</b> <b>8.4</b> 97.2	
Output Shares (%) Coal Peat Oil Gas Comb. Renewables & Wastes Nuclear Livedro	18.7 9.4 31.6 - -	18.5 14.6 3.1 8.6 - 35.3	13.2 5.7 0.9 14.4 12.7 32.1	15.2 8.3 0.9 15.5 11.7 30.6	13.5 6.0 1.6 11.8 15.2 36.7	17.9 5.6 1.7 12.4 15.9 32.4	    
Geothermal Solar/Wind/Other	40.5 - -		20.9 _ 0.1	0.1	- 0.4	- 0.7	
TOTAL LOSSES of which: Electricity and Heat Generation <sup>10</sup> Other Transformation Own Use and Losses <sup>11</sup>	2.0 0.6 0.5 0.9	7.1 5.1 0.6 1.4	8.3 5.8 0.8 1.6	9.1 6.5 1.0 1.7	8.4 7.1 0.7 0.6	8.9 7.5 0.9 0.6	  
Statistical Differences	-0.1	-0.7	-0.0	-0.5	-	-	
INDICATORS							
	1973	1990	2000	2001	2010	2020	2030
GDP (billion 1995 US\$) Population (millions) TPES/GDP <sup>12</sup> Energy Production/TPES Per Capita TPES <sup>13</sup> Oil Supply/GDP <sup>12</sup> TFC/GDP <sup>12</sup> Per Capita TFC <sup>13</sup> Energy-related CO, Emissions (Mt CO <sub>2</sub> ) <sup>14</sup>	81.40 4.67 0.26 0.23 4.57 0.17 0.24 4.16 48.4	133.73 4.99 0.22 0.41 5.85 0.08 0.17 4.56 55.0	166.23 5.18 0.20 0.46 6.37 0.06 0.15 4.78 54.8	167.39 5.19 0.20 0.45 6.52 0.06 0.15 4.86 60.2	209.41 5.26 0.18 0.51 7.15 0.04 0.14 5.56 59.0	260.32 5.29 0.15 0.49 7.59 0.04 0.12 5.91 65.9	    
$(Mt CO_2)$	0.5	2.8	3.2	2.9	1.1	1.1	
GROWTH RATES (% per year)							
	73-79	79-90	90-00	00-01	01-10	10-20	20-30
TPES Coal Peat Oil Gas Comb. Renewables & Wastes Nuclear Hydro Geothermal Solar/Wind/Other	2.3 7.4 48.1 -0.5 -2.4 0.6	1.6 0.6 10.6 -2.3 9.4 2.7 10.0 -0.0	1.2 -1.3 1.7 -0.6 4.6 4.0 1.6 3.0	2.5 15.7 33.4 -2.1 8.3 -1.4 1.3 -9.9 -14.3	1.2 0.3 -0.1 -0.3 2.0 1.7 3.9 -0.2 - 19.6	0.7 2.8 0.4 0.2 0.9 0.8 -0.2 - 6.6	
TFC	0.4	1.2	0.9	1.9	1.6	0.7	
Electricity Consumption Energy Production Net Oil Imports GDP Growth in the TPES/GDP Ratio Growth in the TFC/GDP Ratio	4.7 4.7 1.1 2.4 -0.1 -1.9	4.7 5.9 -3.3 3.3 -1.6 -2.0	2.5 2.3 -0.1 2.2 -0.9 -1.3	2.4 0.1 -2.8 0.7 1.8 1.2	1.7 2.7 -0.7 2.5 -1.3 -0.9	1.0 0.3 0.2 2.2 -1.5 -1.5	

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

# FOOTNOTES TO ENERGY BALANCES AND KEY STATISTICAL DATA

- 1. Peat is shown separately.
- 2. Comprises solid 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 wastes.
- 5. Total supply of electricity represents net trade.
- 6. Includes non-energy use.
- 7. Includes less than 1% non-oil fuels.
- 8. Includes residential, commercial, public service and agricultural sectors.
- 9. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
- 10. Losses arising in the production of electricity and heat at public utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of 33% for nuclear and 100% for hydro.
- 11. 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.
- 12. Toe per thousand US dollars at 1995 prices and exchange rates.
- 13. Toe per person.
- 14. "Energy-related CO<sub>2</sub> 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 2001 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"

Member countries\* of the 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 hydro power, 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 the nuclear

<sup>\*</sup> Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

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.)

# ANNEX

# **GLOSSARY AND LIST OF ABBREVIATIONS**

b∕d	barrels per day
BWR	boiling water reactor
CHP	combined production of heat and power
CO <sub>2</sub>	carbon dioxide
CO <sub>2</sub> eq.	CO <sub>2</sub> equivalent
CDM	Clean Development Mechanism
EC	European Commission
EU	European Union
euro	European currency
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt, or one watt $\times$ 10 <sup>9</sup>
GWh	gigawatt $\times$ one hour
IEA	International Energy Agency
IEP	International Energy Program
ΙΙ	Joint Implementation
kcal	thousand calories
kWe	kilowatt of electric capacity
kV	kilovolt, or one volt $\times$ 10 <sup>3</sup>
kWh	kilowatt-hour, or one kilowatt $\times$ one hour, or one watt $\times$ one hour
km	× 10° kilometre
lca	life-cycle analysis
Lng	liquefied natural gas
MJ	megajoule, or one million joules
Mt	million tonnes
MTI	Ministry of Trade and Industry
	withistry of frade and findustry

Mtoe	million tonnes of oil equivalent
MW	megawatt of electricity, or one watt $ imes$ 10 <sup>6</sup>
MWe	megawatt of electric capacity
MWh	megawatt-hour = one megawatt $\times$ one hour, or one watt $\times$ one hour $\times$ $10^6$
NCS	National Climate Strategy
NESA	National Emergency Supply Agency
NESO	National Emergency Sharing Organisation
NO <sub>x</sub>	nitrogen oxides
Nordel	Association of Nordic Electricity Companies
Nordpool	Nordic Power Market
OECD	Organisation for Economic Co-operation and Development
0&M	operation and maintenance
OTC	over-the-counter
PJ	petajoule, or one joule $ imes$ 10 <sup>15</sup>
PPP	purchasing power parity
R&D	research and development; may include the demonstration and dissemination phases as well (RD&D)
SO <sub>2</sub>	sulphur dioxide
STUK	Radiation and Nuclear Safety Authority
TFC	total final consumption of energy
TJ	terajoule
toe	tonne of oil equivalent, defined as 10 <sup>7</sup> kcal
TPES	total primary energy supply
TSO	transmission system operator
TWh	terawatt x one hour, or one watt $\times$ one hour $\times$ 10 <sup>12</sup>
UN	United Nations
UK	United Kingdom
US	United States
VAT	value-added tax
VOCs	volatile organic compounds

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