NUCLEAR ENERGY IN FINLAND

NATIONAL SURVEY PAPER 2002

May 2002

Prepared for

European Atomic Energy Society

Combined Meeting 2002

Sintra, Portugal

25 - 29 May, 2002

EAES NATIONAL SURVEY PAPER 2002: FINLAND **May 2002**

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1 ENERGY SOURCES AND PRODUCTION IN FINLAND IN 2001

1.1 General Survey

The gross domestic product increased 0.7% last year, dropping significantly from the numbers around 5% in the previous few years. In spite of the small economic growth, energy consumption kept increasing faster than estimated.

The total consumption of energy in 2001 was 1354 PJ or 261 GJ/capita, increasing 3.2% from the 2000 level. As, due to a smaller rainfall in Scandinavia, the net import of electricity decreased by 16% and the hydro power production by 8% (including the 9% drop in wind power production), the increase was mainly compensated by increasing use of coal, peat and natural gas in energy production. As a result, the carbon dioxide emissions related to energy production were 9% higher than in 2000, reaching 60 million tons and exceeding the year 1990 limit set by the Kyoto protocol by some 10%. Part of the increase in energy consumption was due to the 8% growth in heating energy due to colder temperatures in comparison to the warmer-than-average year 2000. Taking into account the temperature variation, the energy consumption increased by 1.4%.

Reflecting the changes in economy, the energy consumption in industry dropped by about 1% and its share of total energy consumption fell slightly below 50%. About two thirds of the industrial energy consumption takes place in forest industry.

After the positive decision in principle made by the Parliament in May 2001 concerning the final disposal facility of spent nuclear fuel from the existing four reactors, the nuclear energy discussion has been dominated by the application by the power company (TVO) for a similar decision in principle concerning the construction of a new nuclear power plant and the management of its spent fuel arising. The parliamentary decision about permitting the industry to build an additional nuclear power plant is planned to take place on May 24, 2002. The vote is expected to be very tight, with around 45% of the MP:s committed to vote on either option and the remaining 10% not having stated their opinion prior to the vote.

1.2 Primary Energy Supplies

The supplies of primary energy from 1985 to 2001 are detailed in Table I and the long-term trend from 1970 onwards is depicted in Fig. 1.

Table I. Primary energy sources (million toe)

	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Oil	9,20	8,97	8,73	8,59	8,22	8,55	8,25	8,47	8,40	8,66	8,72	8,40	8,61
	(36,9%)	*(32,9%)*	*(32,6%)*	*(32,5%)*	*(30,3%)*	*(29,5%)*	*(29,0%)*	*(28,4%)*	*(27,4%)*	*(27,9%)*	*(27,5%)*	*(26,8%)*	*(26,6%)*
Coal	4,00	3,98	3,91	3,38	3,91	4,89	3,98	4,89	4,56	3,54	3,58	3,52	3,89
	(16,0%)	*(14,6%)*	*(14,6%)*	*(12,8%)*	*(14,4%)*	*(16,8%)*	*(14,0%)*	*(16,4%)*	*(14,9%)*	*(11,4%)*	*(11,3%)*	*(11,2%)*	*(12,0%)*
Natural Gas	0,82	2,17	2,29	2,37	2,45	2,70	2,80	2,93	2,87	3,30	3,30	3,38	3,66
	(3,3%)	*(8,0%)*	*(8,5%)*	*(9,0%)*	*(9,0%)*	*(9,3%)*	*(9,8%)*	*(9,8%)*	*(9,4%)*	*(10,6%)*	*(10,4%)*	*(10,8%)*	*(11,3%)*
Nuclear Energy	**4,69**	**4,72**	**4,80**	**4,73**	**4,90**	**4,78**	**4,72**	**4,87**	**5,22**	**5,47**	**5,75**	**5,62**	**5,70**
	(18,8%)	*(17,4%)*	*(17,9%)*	*(17,9%)*	*(18,0%)*	*(16,5%)*	*(16,6%)*	*(16,4%)*	*(17,1%)*	*(17,6%)*	*(18,1%)*	*(17,9%)*	*(17,6%)*
Hydro Power	1,05	0,92	1,12	1,29	1,15	1,00	1,10	1,01	1,02	1,27	1,08	1,25	1,15
	(4,2%)	*(3,4%)*	*(4,2%)*	*(4,9%)*	*(4,2%)*	*(3,5%)*	*(3,9%)*	*(3,4%)*	*(3,3%)*	*(4,1%)*	*(3,4%)*	*(4,0%)*	*(3,6%)*
Peat	0,98	1,34	1,35	1,32	1,39	1,59	1,78	2,02	1,99	1,90	1,67	1,48	1,89
	(3,9%)	*(4,9%)*	*(5,0%)*	*(5,0%)*	*(5,1%)*	*(5,5%)*	*(6,2%)*	*(6,8%)*	*(6,5%)*	*(6,1%)*	*(5,3%)*	*(4,7%)*	*(5,8%)*
Wood based fuels+others	3,80	4,20	3,97	4,05	4,48	4,99	5,13	5,27	5,87	6,12	6,65	6,68	6,57
	(15,2%)	*(15,4%)*	*(14,8%)*	*(15,3%)*	*(16,5%)*	*(17,2%)*	*(18,0%)*	*(17,7%)*	*(19,2%)*	*(19,7%)*	*(21,0%)*	*(21,3%)*	*(20,3%)*
Electricity Imports	0,41	0,92	0,62	0,71	0,65	0,52	0,72	0,32	0,66	0,80	0,96	1,02	0,86
	(1,6%)	*(3,4%)*	*(2,3%)*	*(2,7%)*	*(2,4%)*	*(1,8%)*	*(2,5%)*	*(1,1%)*	*(2,2%)*	*(2,6%)*	*(3,0%)*	*(3,3%)*	*(2,6%)*
Total	24,95	27,22	26,78	26,44	27,15	29,02	28,48	29,76	30,59	31,06	31,71	31,34	32,33

1 toe = 41.868 GJ (1 tce = 0.611 toe). Nuclear energy is given in terms of fuel equivalent based on generation efficiency of 33 per cent.
Hydro power and imported electricity are converted directly to primary energy without taking account of generation efficiency.

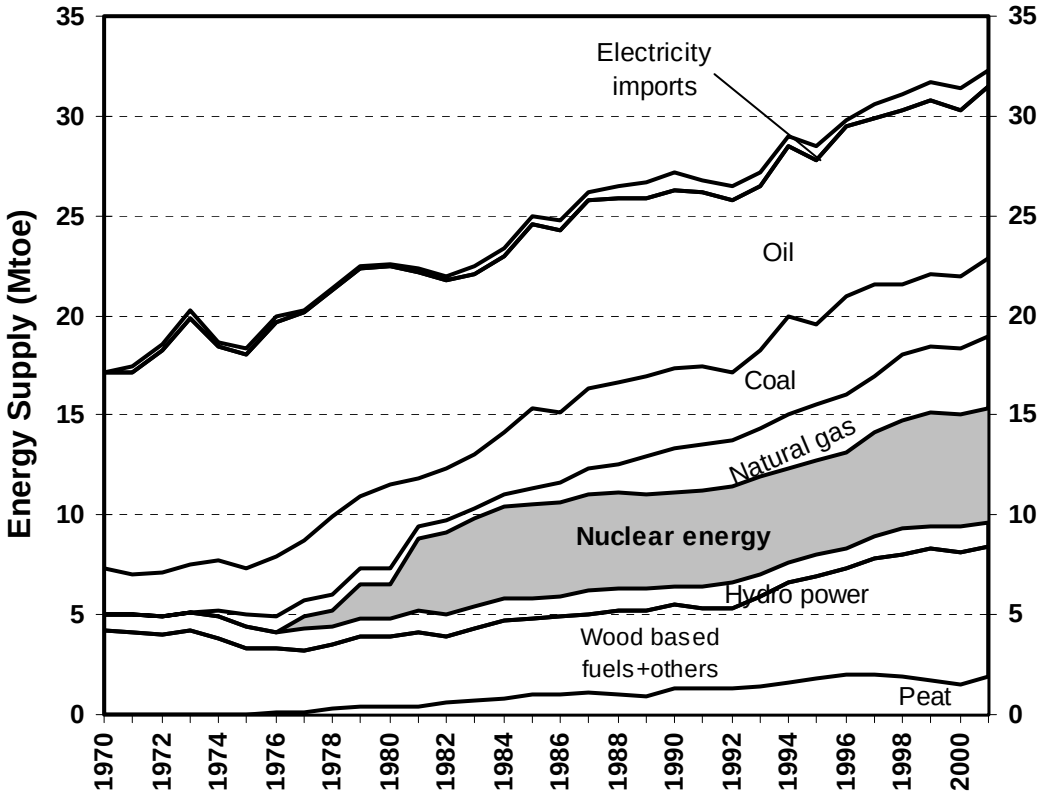

Fig. 1 Energy Supplies in Finland.

1.3 Electricity Production

Table II. Supply of electricity, TWh

	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Hydro Power	12,21	10,75	13,07	14,96	13,34	11,66	12,79	11,70	11,80	14,78	12,55	14,45	13,29
	(25,8%)	*(20,8%)*	*(23,7%)*	*(27,2%)*	*(23,0%)*	*(18,8%)*	*(21,1%)*	*(17,6%)*	*(17,9%)*	*(21,9%)*	*(18,8%)*	*(21,5%)*	*(18,5%)*
Wind Power			0,001	0,002	0,004	0,007	0,011	0,011	0,017	0,023	0,049	0,077	0,071
			(0,002%)	*(0,004%)*	*(0,007%)*	*(0,011%)*	*(0,018%)*	*(0,017%)*	*(0,026%)*	*(0,034%)*	*(0,074%)*	*(0,114%)*	*(0,099%)*
Nuclear Power	17,98	18,13	18,41	18,17	18,80	18,33	18,13	18,68	20,05	20,98	22,06	21,58	21,88
	(38,0%)	*(35,1%)*	*(33,4%)*	*(33,1%)*	*(32,4%)*	*(29,5%)*	*(29,9%)*	*(28,1%)*	*(30,4%)*	*(31,2%)*	*(33,1%)*	*(32,1%)*	*(30,5%)*
Cogeneration,	6,38	7,65	7,32	7,73	8,68	9,48	9,45	9,71	10,98	11,98	12,03	11,74	11,47
industry	*(13,5%)*	*(14,8%)*	*(13,3%)*	*(14,1%)*	*(15,0%)*	*(15,2%)*	*(15,6%)*	*(14,6%)*	*(16,6%)*	*(17,8%)*	*(18,1%)*	*(17,4%)*	*(16,0%)*
Cogeneration,	5,87	8,47	9,28	9,54	9,80	10,72	11,27	12,47	12,23	13,25	12,81	12,72	14,41
district heating	*(12,4%)*	*(16,4%)*	*(16,8%)*	*(17,4%)*	*(16,9%)*	*(17,2%)*	*(18,6%)*	*(18,8%)*	*(18,5%)*	*(19,7%)*	*(19,2%)*	*(18,9%)*	*(20,1%)*
Conv. condensing	4,88	6,59	7,03	4,57	7,38	11,98	8,90	13,79	10,88	6,32	7,16	6,72	10,53
power etc.	*(10,3%)*	*(12,8%)*	*(12,8%)*	*(8,3%)*	*(12,7%)*	*(19,3%)*	*(14,7%)*	*(20,8%)*	*(16,5%)*	*(9,4%)*	*(10,7%)*	*(10,0%)*	*(14,7%)*
Total Production	47,32	51,59	55,10	54,97	58,01	62,18	60,54	66,36	65,95	67,32	66,66	67,28	71,65
	(100%)	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*	*(100%)*
Net Imports	4,73	10,74	7,18	8,23	7,54	6,08	8,41	3,66	7,65	9,31	11,12	11,88	9,96
Total Supply (= Consumption)	52,04	62,33	62,29	63,20	65,55	68,26	68,95	70,02	73,60	76,63	77,78	79,16	81,60

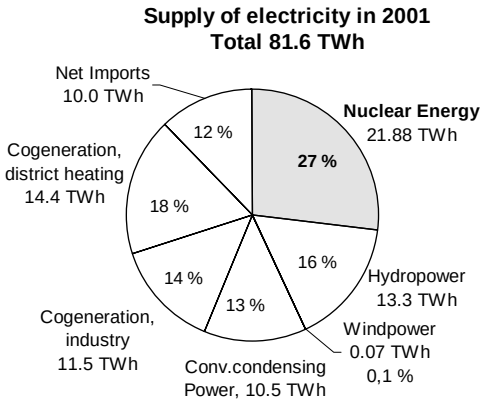

Fig. 2a. Electricity supplies by type of generation in Finland in 2001.

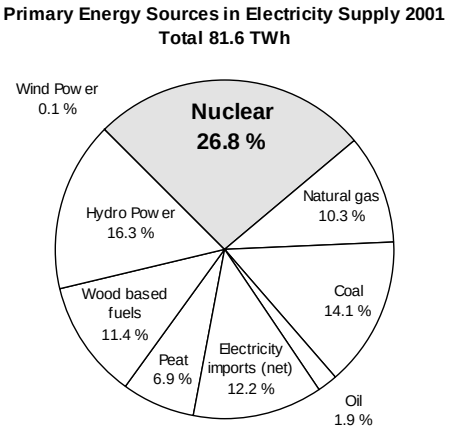

Fig. 2b. Electricity supplies by primary energy sources in Finland in 2001.

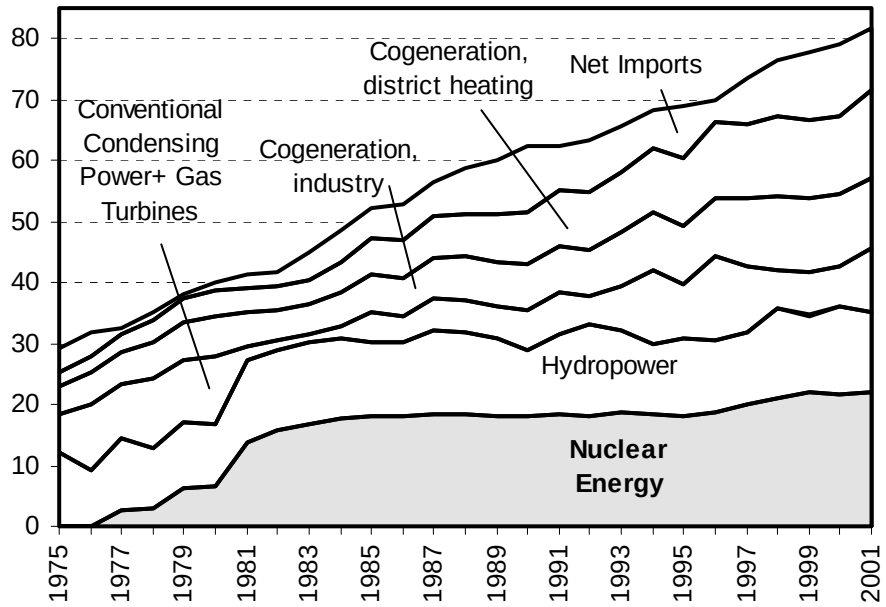

Fig. 2c. Electricity supplies in Finland (1975 — 2001).

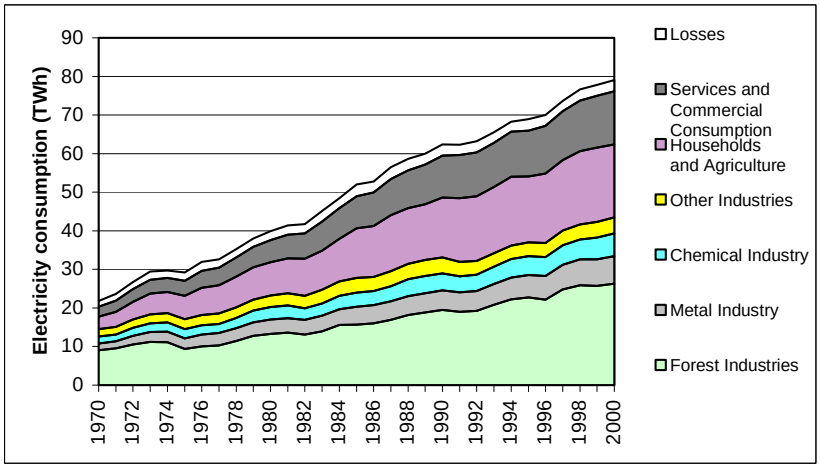

Fig. 3. Electricity consumption in main consuming sectors (1970 - 2000).

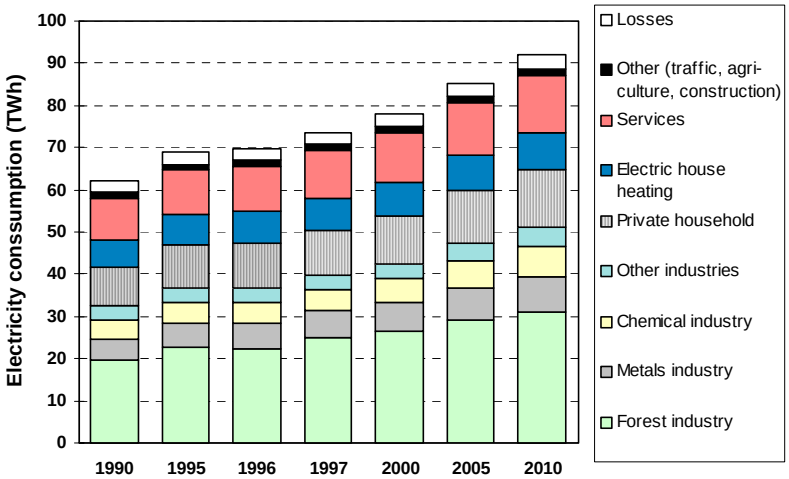

Fig. 4. Development and forecast of electricity consumption in main consuming sectors (1990 - 2010) (Source: Finergy Research Report 3/1997).

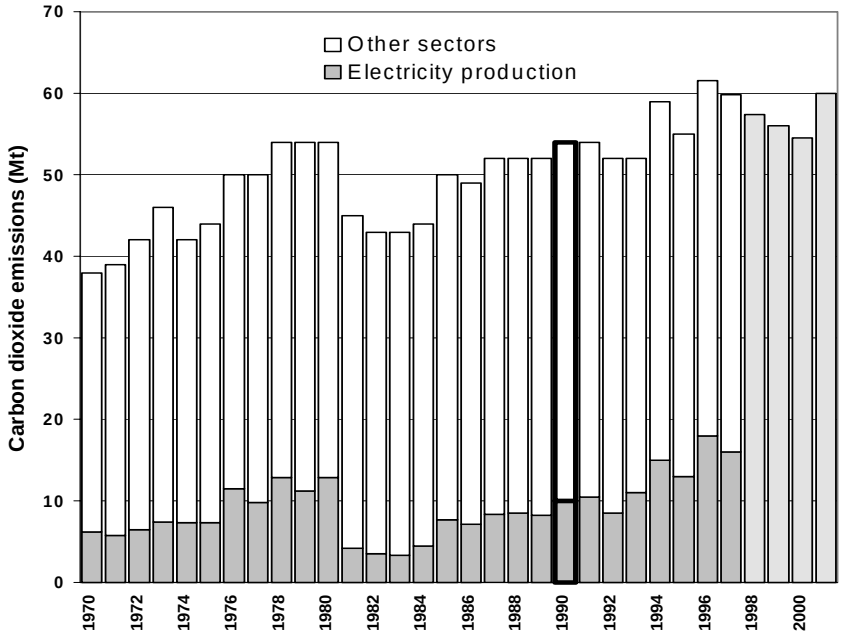

Fig. 5. Development of carbon dioxide emissions in Finland. The share of domestic electricity production was 10 Mt in 1990, 15 Mt in 1994 and 18 Mt in 1996. The NPPs were commissioned in the period 1979 - 1982 replacing conventional condensing power production.

The biggest single CO_2-source of primary energy is oil. In the overall picture (Fig. 6) the emissions from the electricity production are quite small reflecting the efficiency of electricity production (CHP) and the importance of hydro and nuclear power. The share of CO_2-neutral electricity generation is shown in Fig. 7

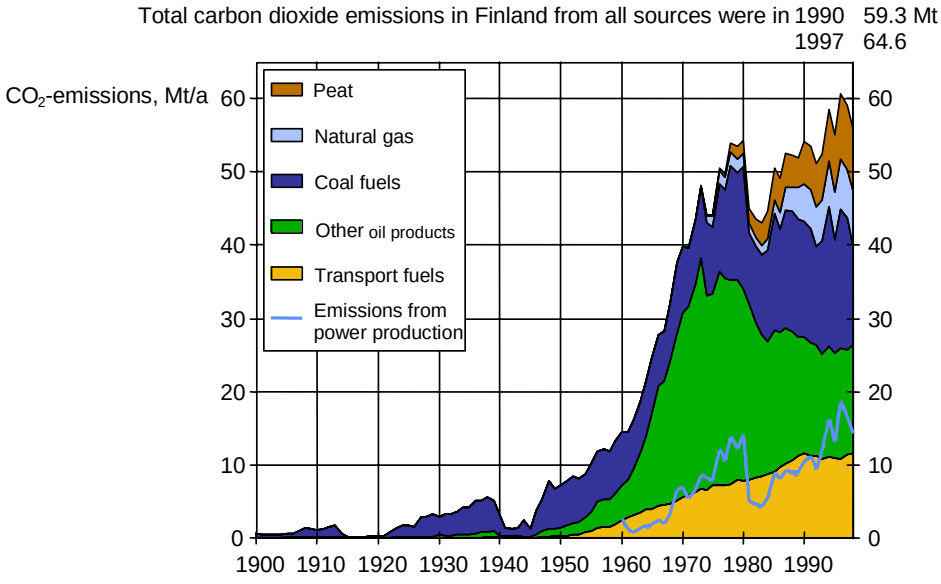

Fig. 6. Carbon dioxide emissions from fuel combustion in Finland.

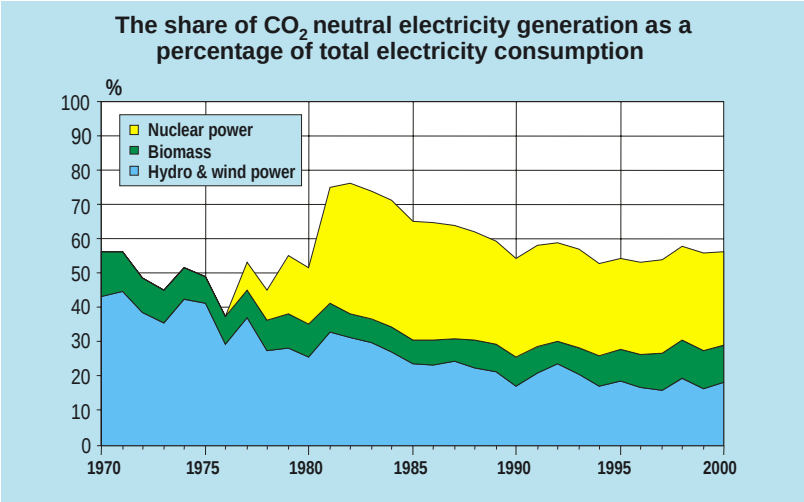

Fig. 7 Share of CO_2 neutral electricity generation

1.4 Climate change

The Government Programme states that "the Government will draw up and implement a national plan on how Finland will meet its minimum obligations on greenhouse gases reached at the Kyoto Conference on climatic impacts. These commitments will be met in such a manner that the measures needed to implement them will not impair economic growth and moves to strengthen employment nor prejudice steps to reduce the national debt."

The preparations for the National Climate Strategy were started sector by sector (the Ministry of Trade and Industry, the Ministry of the Environment, the Ministry of Transport and Communications and the Ministry of Agriculture and Forestry). The Ministry of Trade and Industry has been responsible for coordinating and collecting the sector-specific programmes into a National Climate Strategy in cooperation with the various ministries. For this cooperation, an inter-ministerial Kyoto network was set up. The implementation process of the Strategy has been monitored by a Kyoto Ministerial Working Group.

The sector-specific studies have been compiled into a Background Report to the Government's Climate Strategy. Based on this background report, the Government prepared the National Climate Strategy (www.ktm.fi/ilmasto/selonteko_2305_english.pdf) and submitted it to Parliament in March 2001. The Parliament had its respond debate about the Strategy on June 19, 2001.

During 1999 to 2001 a book *Energy Visions 2030 for Finland* was prepared by VTT Energy. This book included a consideration of three different enrgy scenarios in addition to the reference scenario (business as usual). In the scenario analyses special emphasis was paid on the consideration of the possibilities and economic implications of meeting the Kyoto green house gas emission reduction target and increasingly stringent targets in the future. The main characteristics of the scenarios and the main results are shown in Figs. 8 to 10.

Characteristic	Kyoto	Save	Techno	Reference
Energy and CO_2 taxation	Moderate increase	Large increase	Small increase	Present
Level of energy conservation measures	Moderate	High	Moderate	Low
Costs and potential of renewable energy supply	Base estimates	Base estimates	Boosted development	Conservative estimates
Costs and potential of new technologies	Base estimates	Base estimates	Boosted development	Conservative estimates
Amount of new nuclear capacity allowed	None	1400 MW in 2015	3000 MW by 2030	None
GHG emission reduction objective	The Kyoto target	-20% from 1990 level	-20% from 1990 level	None

Fig. 8. Summary of main characteristics for different energy scenarios

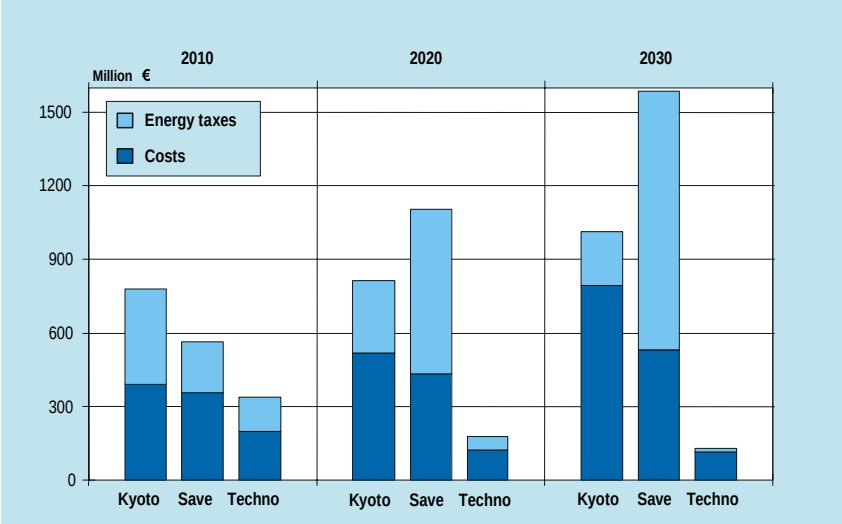

Fig. 9. Cost structures in different energy scenarios

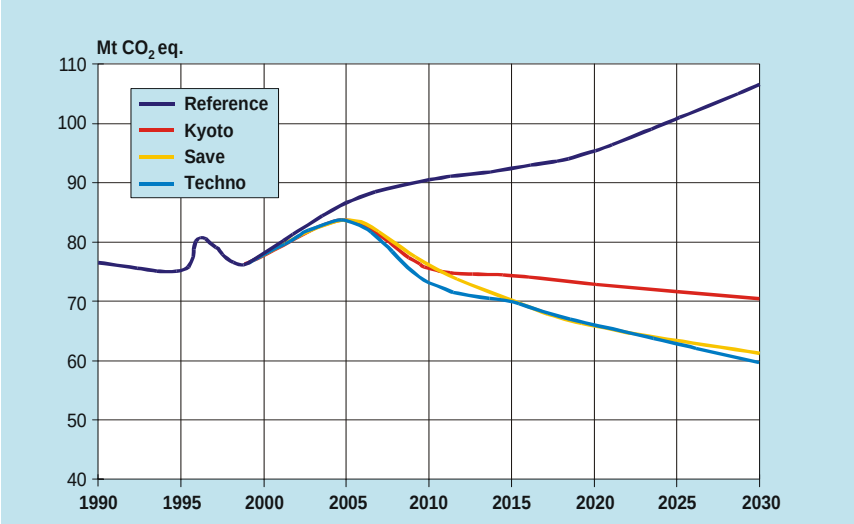

Fig.10. CO_2 emissions in different energy scenarios

2 NUCLEAR POWER

2.1 Nuclear Power Plants

2.1.1 Nuclear Power Statistics 2001

During 2001 all the Finnish nuclear power units operated reliably. At the Loviisa VVER:s, there was one unexpected shutdown due to a cable break, and two production outages needed for checks related to an oil leak from a main circulation pump and a leaking control rod shroud tube. No events above INES 0 were reported. The durations for the revision outages for the two units were 20 and 22 days, respectively.

At the Olkiluoto BWR:s, there was one unexpected shutdown due to a turbine operation failure. No other unexpected production outages occurred. A similar gearwheel fault found at several emergency cooling system valves was rated INES 1; no other events above INES 0 were reported. The revision outages at the two units lasted 8 and 15 days, respectively.

Table III. Characteristics of the Finnish nuclear power plants and main production statistics for **2001**

Unit	Nominal Capacity, MW(e) (gross/net)	Start-up	Commercial Operation	Annual Electricity Generation, TWh (net)	Load Factor per cent	
					Annual	Cumulat. [2]
Loviisa 1	510/488	1977	1977	3.92	92.1	84.6
Loviisa 2	510/488	1980	1981	3.78	89.0	87.7
Olkiluoto 1	870/840	1978	1979	7.16	97.6	90.9
Olkiluoto 2	870/840	1980	1982	7.03	95.1	92.4
All units	2760/2656			21.56	94.2[1]	89.6

[1] Gross capacity weighted average; the arithmetic average is 93.5 %

[2] From the start of commercial operation

2.1.2 General Survey of Reactor Performance

The historical trends in annual and cumulative load factors of the Finnish nuclear power plants are shown in Figs. 11 and 12, respectively. The development of annual occupational collective doses (manSv/a/station) of the Finnish nuclear power stations (both with 2 reactor units) are shown in 13. All the reactors in Finland operated without significant disturbances throughout the year 2001 The annual number of abnormal events according to the INES-scale is depicted in 14.

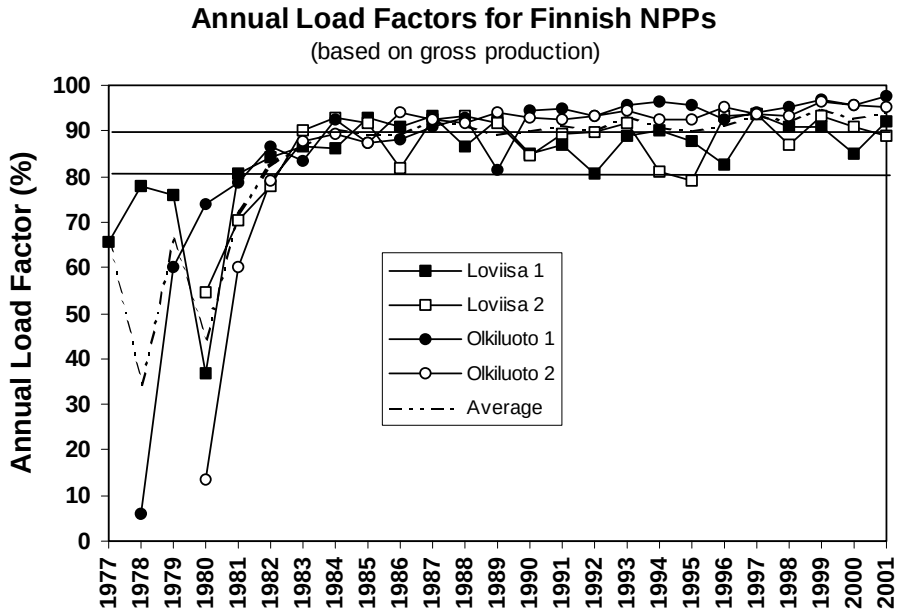

*Fig. 11. The development of **annual load factors** of the Finnish nuclear power plants*

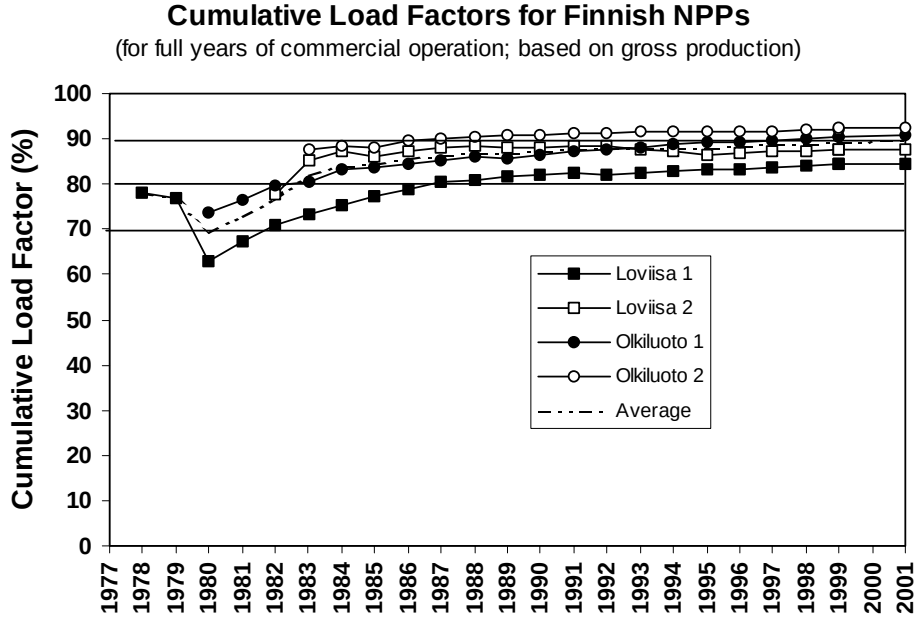

*Fig. 12. The development of **cumulative load factors** (from the beginning of commercial operation) of the Finnish nuclear power plants.*

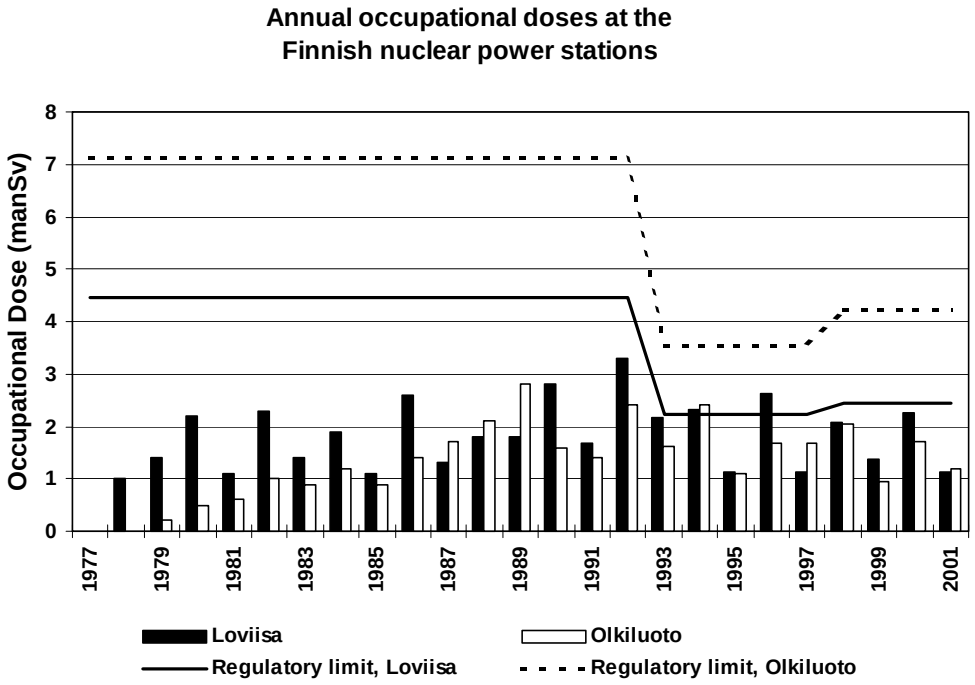

*Fig. 13. The **annual occupational doses** of the Finnish nuclear power stations are compared with the authority limits. The tightened regulatory limit for annual occupational dose of 2.5 manSv/GWe went into force at the beginning of 1993 in lieu of the previous limit of 5 manSv/GWe*

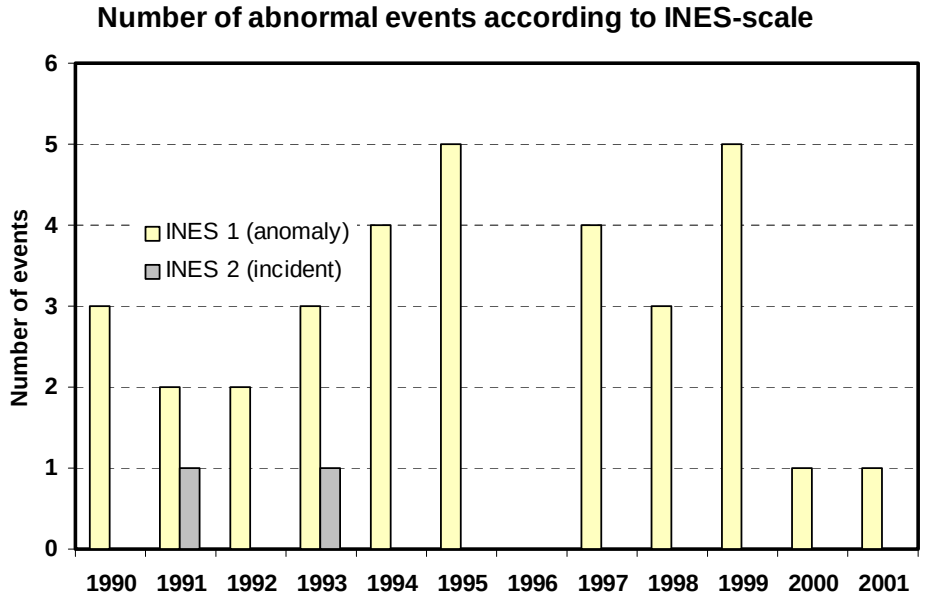

Fig. 14 The total annual number of abnormal events (anomalies & incidents) according to the International Nuclear Events Scale (INES) at the Finnish nuclear power plants.

2.2 The outlook of nuclear power in Finland

Finland is one of the few European countries seriously considering increasing the use of nuclear power. Key reasons especially for the energy-intensive industry to increase nuclear power capacity include the good experiences with the existing nuclear power plants and particularly the steady price of electricity generated in them, Finland's small indigenous energy resources, and the efforts to restrict the use of fossil fuels in order to prevent the threatening climate change. Also the citizens have a more positive attitude towards an increase in nuclear power in Finland than in most other countries. In recent polls, the numbers of opponents and proponents to a new NPP have been very close to each other, both around 45%.

Finnish nuclear power companies have followed closely the development of nuclear power plant technology in the 1990s and also participated in certain plant development projects. They have also taken part in the European Utility Requirements (EUR) programme, in which the design requirements for new nuclear power plants to be built in Europe have been defined in co-operation with European power companies.

In 1998, the nuclear power companies launched the procedure in accordance with the legislation on environmental impact assessment in order to study the environmental effects of a new nuclear power plant unit, if it were to be built in Loviisa or Olkiluoto. The companies handed over the results of the environmental impact assessments, the so-called EIA reports, to the Ministry of Trade and Industry in August 1999. In the reports, the environmental impacts of nuclear power plant units of the BWR and PWR type are assessed. The environmental impact assessment process was completed in February 2000 when the Ministry of Trade and Industry gave its final statement on the reports concluding that the environmental impacts have been studied in sufficiently comprehensive scope.

In early autumn 1999, Fortum and TVO decided that TVO is to be responsible for the possible implementation of a new nuclear power unit. As locations, Loviisa and Olkiluoto compete as equal alternatives, as do the boiling water and pressurised water technologies as technical alternatives. The plant type and location will be decided in due course on the basis of technological and economical factors.

In November 2000, TVO filed an application for a decision in principle to the Government concerning the construction of a new nuclear power plant unit. In the application, the size of a new unit is defined at 1 000 – 1 600 MW with a technical operating life of 60 years. The application also includes the nuclear facilities needed for the handling, storage and final disposal of operating waste.

On January 17th 2002, the Finnish government decided that constructing the new nuclear power plant unit planned by TVO would be in line with the overall good of the society. The Parliament Commerce Committee has now prepared a report on the decision in principle. This report will form the basis for the Parliament vote on nuclear power, scheduled to take place on Friday, May 24th 2002.

Seven other committees have prepared their statements to the Commerce Committee. The Social Affairs and Health Committee submitted their statement on March 23rd 2002. The statement neither supports nor opposes the construction of nuclear power, but merely lists positive and negative viewpoints. The Administration Committee made their statement on April 3rd, 2002. The statement contains no bearing on constructing additional nuclear capacity, but states that "As a whole, the current legislation and procedures derived from it, as well as their principles, are suitable for use as a basis for planning the preparation and safety measures of a potential new power plant unit."

The Environment Committee stated an adverse opinion on April 24th 2002, based on a voting result of 10 against, 6 for and 1 abstention. The Agriculture and Forestry Committee supported nuclear power on April 24th with 10 members for, 6 against and 1 abstention. The Committee for the Future submitted their statement on April 24th. The committee does not present an opinion on nuclear power, but asks for the Commerce Committee to take the positive and negative viewpoints listed in the statement into account. The Finance and Employment and Equality Committees submitted their statements on April 26th 2002.

If the Government´s Decision in Principle will be endorsed by the Parliament in the decisive voting on May 24th, 2002, a new nuclear power plant unit could be in commercial use by 2010.

2.3 Nuclear Fuel Supply

2.3.1 Uranium Supply, Enrichment and Reprocessing

After joining the European Union the requirements of Euratom have been adopted in nuclear fuel supply to the Finnish NPPs. Fortum Power and Heat (formerly Imatran Voima Oy, IVO), the operator of the Loviisa NPP, has continued the efforts for acquiring an optional fuel supplier from western sources besides the present Russian fuel supplier. Together with the Hungarian Paks utility, test fuel assemblies have been bought from the BNFL. Five lead assemblies from BNFL were loaded in Loviisa in 1998. In December 1999, Fortum Power and Heat announced that at least half of the fuel loaded into the two Loviisa VVER plants between 2001 and 2005 will be bought from BNFL. The first batch of BNFL fuel was loaded into one of the Loviisa reactors in the 2001 revision.

2.4 Progress in spent fuel disposal program

2.4.1 Progress in the first licensing stage for spent fuel disposal facility in Finland

According to the Nuclear Energy Act, the first authorisation step towards a disposal facility for nuclear waste is the so-called Decision in Principle (DiP). At this step the Government shall consider whether "the construction project is in line with the overall good of society". In particular, the Government shall pay attention to the need of the facility, to the suitability of the proposed site and to the environmental impacts from the proposed practice.

The multi-phase process for selecting the site for a spent fuel disposal facility has lasted about two decades. During the whole process the developer, first TVO and subsequently Posiva, has had active contacts to the decision makers and the general public in the candidate municipalities. In fact, both the Nuclear Energy Act and the EIA Act require that public hearings have to be arranged. The site selection process culminated in the combined EIA- and DiP- processes during the years 1997 to 2001.

Posiva Oy started the formulation of the EIA programme at all four candidate sites (Eurajoki, Kuhmo, Loviisa, Äänekoski) in the early 1997. At this stage, a comprehensive public interaction programme was launched consisting of a large number of public meetings and brainstorming sessions, distributing various printed material and videotapes and different presentations at local fairs and other public gatherings. The EIA programme was officially submitted to the Ministry of Trade and Industry (the contact authority) in February 1998 and, on the basis of public hearings and comments from a number of parties concerned and expert bodies, the Ministry gave its statement on the programme in June 1998. In accordance with the Espoo Convention the neighbouring countries Sweden, Russia and Estonia were notified of the EIA programme.

Posiva Oy submitted the completed EIA report together with a comprehensive set of supporting documents to the Ministry of Trade and Industry in spring 1999. After that the Ministry asked for statements from local and national authorities and opinions from the public on the EIA report. After the hearings, the Ministry gave in November 1999 its statement, which completed the EIA process.

At the same time as the EIA report was submitted to the Ministry in May 1999, Posiva Oy submitted the Decision in principle (DiP) application to the Government. The DiP application addressed only one site candidate in the vicinity of the Olkiluoto NPP site in the Eurajoki municipality. As described in Table 2, the DiP-process was completed in May 2001, when the Finnish Parliament ratified the Government's decision.

The EIA and DiP processes were quite demanding for both Posiva and the authorities. The Public Sector's Research Programme on Spent Fuel Management had a significant role in supporting the activities of the authorities in these processes. The support included among others assistance in developing the basic EIA procedures, follow-up of the EIA- and DiP-processes, evaluation of the key documents produced by Posiva Oy and providing impartial special reports on spent fuel management for non-technical audience.

After the positive conclusion of the DiP-process, the planned next stage of the Finnish final disposal programme will include an underground research facility ONKALO in Olkiluoto, the construction of which is scheduled to start within a few years. The construction of the disposal facility is scheduled to start in early 2010's and the actual final disposal activities would start some ten years later. These implementation stages will, however, need a construction licence from the Government, and later a separate operation licence.

In its application for DiP for spent fuel disposal facility, Posiva also proposed that spent nuclear fuel generated from the operation of a potential new nuclear power plant unit to be constructed in Finland would be disposed of at the final disposal plant in question. The Government decided to consider this point of the application later in the same connection as it will deal with the pending application submitted by Teollisuuden Voima Oy in November 2000 on the construction of a new nuclear power plant unit. (cf. section 2.2)

2.4.2 Financial Provisions

To ensure that the financial liability is covered, the utilities must each year present cost estimates for the future management of nuclear wastes. The cost estimates, based on the existing waste quantities and including decommissioning of NPPs, amount to about 1200 million euros with no discounting.

The utilities are obliged to set aside a certain amount of money each year to the State Nuclear Waste Management Fund. The past and expected future development of the total fund holdings and unfunded liabilities are depicted in Fig. 15. At the end of the year 2001 the funded money covered the whole liability.

The administrative procedures are described in detail in the nuclear energy legislation. In rough terms, the cost for radioactive waste management, including plant decommissioning, is 0.00023 Euro/kWh (with no discounting), about 10 % of the total power production cost

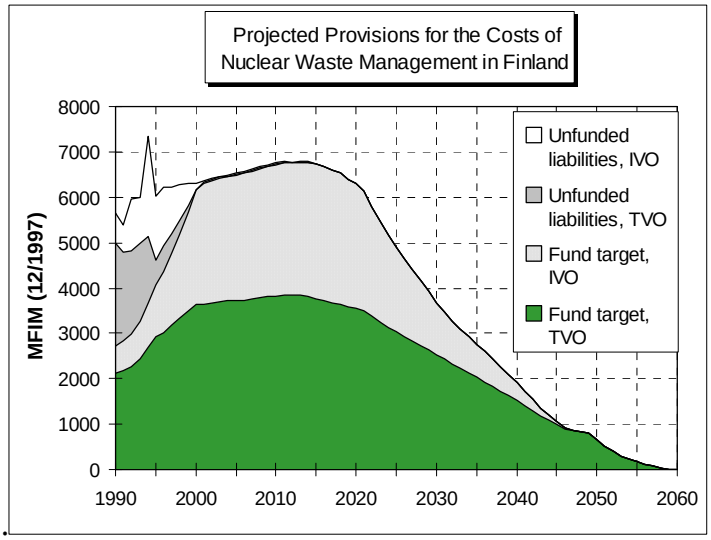

Fig. 15. Fund holdings in the Nuclear Waste Management Fund and unfunded liabilities covered by securities (1 FIM = 0.17 euro).

2.5 Nuclear R&D

2.5.1 Policy

The focus of nuclear R&D is on the safety and operational performance of the power plants and on the management and disposal of wastes. Publicly funded nuclear energy research provides impartial expertise for the regulation of nuclear energy. The public sector also plays a major role in ensuring the necessary personnel and equipment resources for research and development, as well as in establishing the framework for international collaboration.

For nuclear fission energy, the Ministry of Trade and Industry (KTM), the major funding source, has contracted the Technical Research Centre of Finland (VTT) to manage the research programmes on nuclear fission safety. VTT also carries out most of the research work. Other significant research institutions include the Geological Survey of Finland, the University of Helsinki, Lappeenranta University of Technology, Helsinki University of Technology, the Finnish Meteorological Institute and the Radiation and Nuclear Safety Authority (STUK).

That part of the research, which is funded and also partly carried out by the power companies, Fortum Engineering and TVO, concentrates on plant-specific issues (e.g. plant modernisation, severe accident management, PSA, ageing phenomena) and nuclear waste disposal.

Effort is made to harmonise the objectives of national research programmes as much as possible with the research fields and priorities of major international nuclear energy co-operation programmes, both within the European Union, OECD/NEA and the Nordic Countries.

2.5.1.1 Research programmes

To make publicly funded nuclear energy research result-oriented and efficient, to strengthen the basic and advanced education of experts, and to facilitate international co-operation, most of the research was organised as national research programmes in 1989. Currently, the third and partially fourth generation of programmes are under way. The programmes in progress are:

- Nuclear Power Plant Safety (FINNUS), 1999 - 2002
- Finnish Fusion Programme (FFUSION2) 1999 - 2002.
- The National Research Programme on Nuclear Waste Management (KYT), 2002 – 2006.

The total volume for the research programmes on nuclear fission energy is about 50 person-years annually. Nuclear fusion research comprises about 25 person-years. At present, the total annual volume of all nuclear energy research in Finland is estimated to be some 200 person-years.

2.5.2 Fuel Cycle

Research on the fuel cycle is aimed at efficient fuel utilisation with advanced in-core fuel management schemes, increasing the burn-up and introducing new fuel designs. This includes the development of computational capabilities for reactor physics calculations, the analyses of fuel performance with computer models and the participation in international experimental research projects on light water reactor fuel behaviour.

The Finnish limits regarding the maximum allowed discharge burnup of spent nuclear fuel have traditionally been quite conservative, in practise limiting the assembly-averaged burnup to 40 MWd/kgU. The power company TVO is currently running a research project in order to be able to expand this limit to at least 45 MWd/kgU within the next few years.

2.5.3 Waste Management

In the waste management studies emphasis is paid on spent fuel management. The waste management research in Finland is being conducted both in the national research programme (KYT) and, primarily, in the R & D programme by Posiva Oy and the utilities. Furthermore, the Safety Authority (STUK) orders independent studies for the support of its licensing review assessments.

After the Decision in Principle in 2001 for a spent fuel disposal facility in Eurajoki the next milestone in Finnish nuclear waste management programme will be the constructing license for the facility around 2010. To reach this ambitious goal, however, requires even more high-quality and focused research than before. The Ministry of Trade and Industry started a five-year research programme in February 2002 called the National Research Programme on Nuclear Waste Management (KYT). The most important research area of the KYT-programme is long term safety of spent fuel repository. The KYT-programme is based on co-operation of all main actors in Finnish nuclear waste management, including regulators and implementers. This "unholy alliance" provides pragmatic viewpoints to the research programme but it also requires balanced research that does not compromise the respective interests of regulators and implementers.

2.5.4 Safety and Environment

The Finnish Research Programme on Nuclear Power Plant Safety, FINNUS 1999-2002, combines the aspects of reactor operation and structural integrity. The three main themes of the programme, **ageing, accidents and risks** are covered with 11 research projects.

The projects are mainly carried out at VTT, utilising its experienced personnel, experimental facilities and computational capabilities.

The programme was planned together with the safety authority, the Finnish nuclear power companies and the research organisations and launched by the Ministry of Trade and Industry.

FINNUS briefly:	
Research fields:	• Nuclear power plant ageing • Accidents • Risks
Duration:	1999-2002
Total budget:	Euro 17 million
Volume in 2002:	Euro 3.54 million, out of which one third by Ministry of Trade and Industry
Research Partners:	VTT Processes, VTT Industrial Systems, VTT Building Technology, Fortum Power and Heat Oy, Lappeenranta University of Technology
Co-ordination:	VTT Processes
Web Site:	http://www.vtt.fi/ene/program/finnus/

Component Life Management, XVO 1999-2002.

The Finnish nuclear power plants have operated more than 20 years. Significant research efforts on critical components' ageing and lifetime management are invested to maintain excellent usage factors and continue operation long in future. For that purpose VTT and industry together planned a set of annual R&D projects to be performed in 1999 - 2002.

The projects deal with systematic component lifetime management, piping vibrations and integrity, materials ageing, NDE, interactions of coolant and materials, environmentally assisted cracking and ageing of reactor internals.

VTT Industrial Systems carries out a major part of the project. Helsinki University of Technology performs the included basic research tasks. Teollisuuden Voima Oy (TVO) and Fortum finance the project together with the National Technology Agency (Tekes).

3 TECHNICAL RESEARCH CENTRE OF FINLAND (VTT)

3.1 Research Programme

From the beginning of 2002, VTT revised the organisation adopted in 1994 and slightly revised already in 2001. Presently there are six research institutes. The previous institutes **VTT Energy** and VTT Chemical Technology were merged into VTT Processes and VTT Automation and VTT Manufacturing Technology into VTT Industrial Systems. The current six research institutes are:

- VTT Electronics
- VTT Information Technology
- VTT Industrial Systems
- VTT Processes
- VTT Biotechnology
- VTT Building and Transport

The mission and the vision of the new VTT Processes institute are:
We are a research & development partner for process industries and the energy sector and provide support for the decision making in the public sector. With our science-based innovations we enhance the technical and economic performance of our clients and improve the well-being of the society. We are the forerunner in the development and application of efficient and environmentally friendly energy and process technologies as well as new materials.

In 2002, VTT Processes covers the six research fields described in Table IV.

Table IV. Planned volumes and sources of income of the research fields of VTT Processes in 2002.

Research Field	Volume (person-years)
Nuclear Energy	80
Energy Production	120
Emission Control	**90**
Systems and Models	90
Paper and Mineral Industries	115
Materials and Chemicals	120

Fig. 16 indicates the current research fields and research groups in VTT Processes.

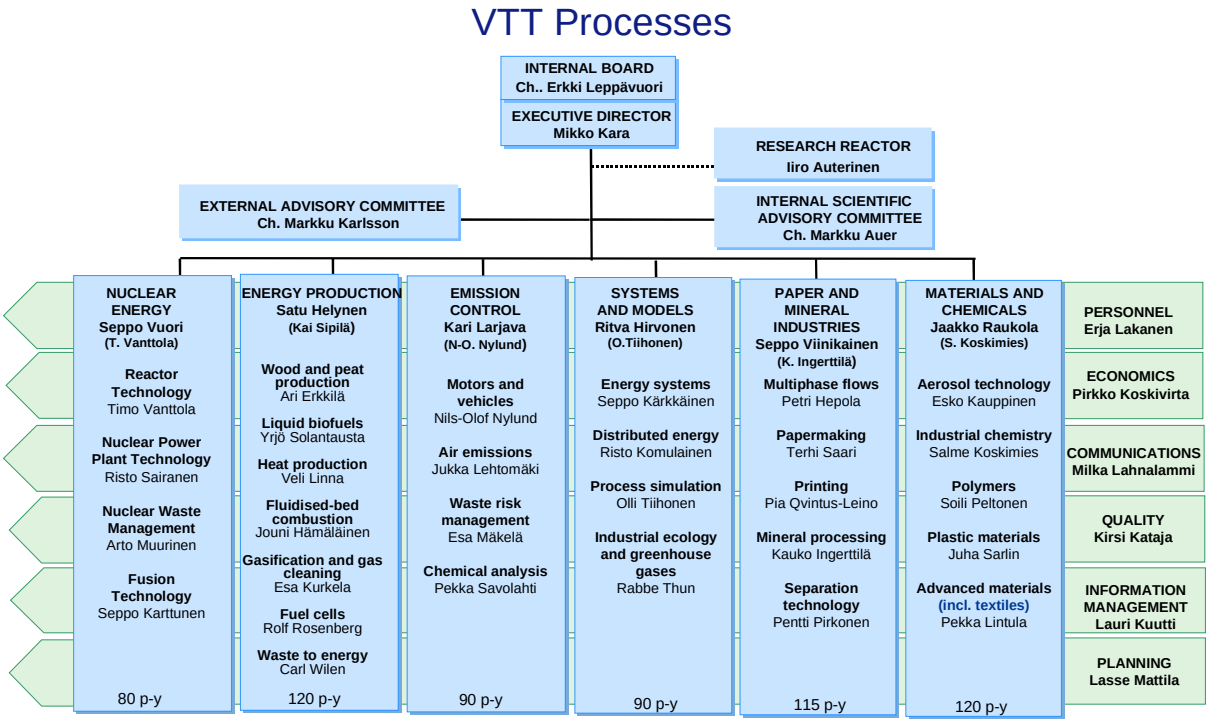

Fig. 16. Organisation of VTT Processes in 2002.

3.2 Funding

Fig. 17 depicts the development of VTT´s income from contract research by customer sector in the period 1989 to 2002. More detailed information is given in VTT's Annual Report 2001. (Can be downloaded from: *www.vtt.fi/annualreport/annual01.pdf*).

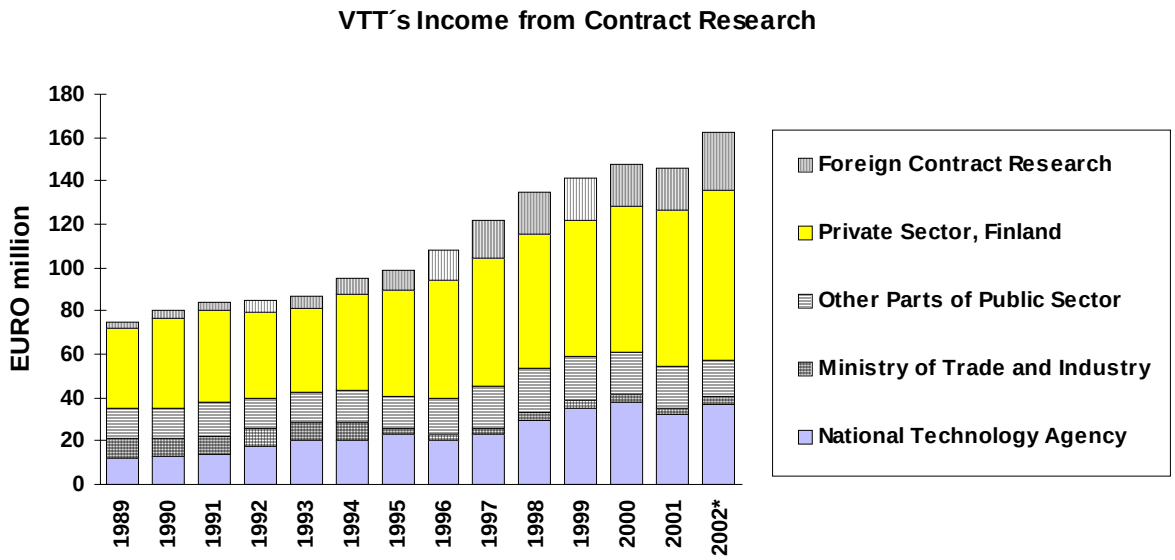

Fig.. Development of VTT's income from contract research by customer sectors.