THE NEW NUCLEAR POWER PLANT IN FINLAND

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CONTENTS OF THE PRESENTATION

• Culmination: Parliament Decision 2002
• Description of the new nuclear power unit
• Power sector in Finland
• Liberalized power market
• Economic comparison of power plants
• Public and political discussion; main topics
• Carbon dioxide emission trading
• Arguments for the new nuclear power unit and conclusions
Culmination:
THE FINAL SCORE
For nuclear 107, against nuclear 92
NUCLEAR ENERGY YOUTH CELEBRATING IN FRONT OF THE PARLIAMENT HOUSE ON 24 MAY 2002.
Finland – Greenpeace 5 - 0
ADVANCEMENT OF THE DECISION TO
CONSTRUCT THE FIFTH NUCLEAR UNIT

- TVO submitted the environmental impact assessment reports to Ministry of Trade and Industry in August 1999
- TVO submitted its application for a decision-in-principle to Ministry of Trade and Industry on 15 November 2000
- The Government made a decision-in-principle on 17 January 2002 (The decision will be in force for five years after the Parliament’s approval)
- Parliament voted on the decision-in-principle in its plenary session on 24 May 2002 and ratified it with 107 votes in favour and 92 votes against
- Commissioning 2009
NUCLEAR POWER IN FINLAND

Start-up

Lovisa 1: 1977 (420 MW)
Lovisa 2: 1980 (420 MW)
Olkiluoto 1: 1978 (660 MW)
Olkiluoto 2: 1980 (660 MW)

Present situation:

Lovisa: 2 × 488 MW
Olkiluoto: 2 × 840 MW
Total 2656 MW

In 2001:

Production 21.85 TWh
Average load-factor 93.9 %
Clear drop in CO₂ emissions after 1980 when nuclear generation started
DESCRIPTION OF THE NEW NPP

- Owner: Teollisuuden Voima Oy (TVO) (internet: www.tvo.fi)
- The shareholders of TVO: Industrial companies and power companies (also small electricity distribution utilities)
- Location: Olkiluoto on the west coast of Finland.
- The new NPP is called OLKILUOTO 3
- Construction 2004-2009
- EPR – PWR 1600 MWe
- 3 billion € (3000 million €) = Turn-key investment cost including IDC (interest during construction)
- 1875 €/kW
- Thermal efficiency 37 %
- 13 TWh/a or 15 % of the demand of Finland
### Reactor main data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reactor thermal power</td>
<td>4300 MW</td>
</tr>
<tr>
<td>Electric output</td>
<td>approx. 1600 MW</td>
</tr>
<tr>
<td>Reactor pressure</td>
<td>154 bar</td>
</tr>
<tr>
<td>Steam temperature</td>
<td>290 °C</td>
</tr>
<tr>
<td>Pressure vessel height</td>
<td>13 m</td>
</tr>
<tr>
<td>Reactor core height</td>
<td>4.2 m</td>
</tr>
<tr>
<td>Number of fuel elements</td>
<td>241 pcs</td>
</tr>
<tr>
<td>Uranium in reactor</td>
<td>128 ton UO₂</td>
</tr>
<tr>
<td>Number of control rods</td>
<td>89 pcs</td>
</tr>
<tr>
<td>Containment height</td>
<td>63 m</td>
</tr>
<tr>
<td>Containment width</td>
<td>49 m</td>
</tr>
<tr>
<td>Containment wall thickness</td>
<td>2 m</td>
</tr>
</tbody>
</table>
The reactor plant of the Olkiluoto 3 will be supplied by the French-German company Framatome ANP and the turbine plant by the German Siemens.

The new unit is a pressurized water reactor plant with net electric output of about 1600 MWe. The planned operational lifetime of the unit is 60 years. International safety regulations as well as valid Finnish safety requirements have been taken into consideration in the plant design. The new plant unit also fulfils the technical and safety requirements (EUR, European Utility Requirements) defined by European power companies. The Radiation and Nuclear Safety Authority of Finland performed a preliminary safety assessment for the plant unit in connection with the handling of TVO's application for the decision in principle in 2001.
Olkiluoto 3 Schedule

- Main contract
- Construction Licence
- Site works
- Civil works
- Installation
- Operation License
- Start-up
- Commercial operation
POWER AND ENERGY SECTOR IN FINLAND

- Many sources of electricity
- High share of CHP electricity
- High share of bioenergy
- Consumer prices of electricity quite low
- GHG emissions exceeding the Kyoto commitment of 78 MtCO2 (2010: 90 MtCO2 without new nuclear)
- The share of coal power and electricity imports too high
- Dynamical business situation: Open market and Emission trading as well as possible Changes in government taxes and subsidies (and EU directives!)
Net Supplies of Electricity 2003
84.7 TWh

- Nuclear power: 25.8%
- Co-generation (CHP), district heating: 18.6%
- Co-generation (CHP), Industry: 15.2%
- Condense etc: 23.6%
- Net imports: 5.7%
- Hydro power: 11.0%
- Wind power: 0.1%
Electricity Supply by Energy Sources 2003

84.7 TWh, fuels are estimated

- Nuclear power: 25.8%
- Coal: 21.6%
- Natural gas: 13.0%
- Other renewable: 13.1%
- Peat: 7.6%
- Wind power: 0.1%
- Net imports: 5.7%
- Hydro power: 11.0%
- Oil: 2.1%
Electricity Consumption 2003
84.7 TWh

- Industry: 53%
- Household: 22%
- Agriculture and housing: 12%
- Public: 6%
- Service: 4%
- Losses: 4%

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Electricity Consumption

Statistics
Forecast

TWh
Electricity Consumption in Finland until 2020

Source: Finnish Energy Industries Federation FINERGY
Peek Load of Electricity

Source: Finnish Energy Industries Federation FINERGY
Electricity imports from Russia in 2003

- Fortum 300 MW
- Norsk Hydro 300 MW
- Pohjolan Voima PVO 400 MW
- RAO Nordic 250 MW
- RWE 50 MW

Totals 1300 MW
Energy supply in Finland by countries of origin in 2001

Domestic 29 %
Import 71 %

In total 33.5 Mtoe

Russia 54 %
Norway 12 %
Denmark 11 %
Sweden 6 %
Others 17 %
Electricity Consumption per capita 2001
EU - Countries

Portugal
Greece
Italy
Spain
Ireland
Great Brit.
Germany
Denmark
Netherlands
Austria
France
Belgium
Luxembourg
Finland
Sweden

Sources: Eurostat, IAEA, Nordel Årsberättelse 2001

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Electricity Prices in EU countries
January 1st 2003, Households

Greece
Finland
Great Britain
Spain
France
Ireland
Portugal
Luxembourg
Sweden
Austria
Belgium
Germany
Netherlands
Italy
Norway
Denmark

Source: Eurostat
The price of electricity for households

- Procurement: 33%
- Distribution of electricity: 31%
- VAT: 18%
- Electricity taxes: 8%
- Electricity sales: 6%
- Transmission in national grid: 2%
- Transmission in regional network: 2%

1.10.2003 total 9.99 cnt/kWh
Electricity Prices in EU countries
January 1\textsuperscript{st} 2003 Medium-Scale Industry

Great Britain
Spain
Norway
France
Finland
Greece
Sweden
Portugal
Denmark
Belgium
Ireland
Luxembourg
Germany
Italy

Excl. taxes
Taxes

Source: Eurostat
Total Energy Consumption in Finland 2002

- Oils total: 26%
- Coal: 20%
- Natural gas: 11%
- Nuclear power: 13%
- Wood fuels: 17%
- Hydro and wind power: 3%
- Peat: 6%
- Others: 3%
- Oils total: 1%

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Finland’s greenhouse gas emissions

Figures 1990-2001 according to official reporting. 2002-2010 schematic estimates
LIBERALIZED POWER MARKET

• New electricity market act in 1995
• Finnish Power Grid Plc (Fingrid) founded in 1997, national transmission grid, 400 and 220 kV lines as well as cross-border lines
• Free access to the national grid
• Open market in the Nordic countries (Norway, Sweden, Finland, Denmark)
• High share of hydro power
• Nordpool (Power Exchange pool)
• Functioning effectively (best in the world)
• Spot price of electricity strongly dependent on the rainfall and water storage situation
Generation in the Nordic Countries 2002

- **Hydro power**: 55%
- **Nuclear power**: 22%
- **Thermal power**: 21%
- **Wind and geothermal power**: 1.8%

Total generation: 392 TWh

- 131 TWh (8%)
- 143 TWh (87%)
- 37 TWh (17%)
Reservoir Content of
the Nordic Electrical Exchange Area

100 % = 120.4 TWh http://www.nordpool.com/
NORDIC TRANSMISSION CAPACITIES (MW)
2004

Present capacity
Under planning

NORDIC TRANSMISSION CAPACITIES (MW)
2004
Nordic system price and area price for Helsinki 1.1.1999-11.6.2004 (hourly prices)
FUTURE MARKET PRICE? SECURITY OF SUPPLY!!

- Nordpool forwards for the years 2006 and 2007 are now (17.6.2004) 29.4 €/MWh
- No other future market price information available
- Power companies are no more responsible for reserve capacity; Fingrid has taken over the responsibility for reserve capacity
- Security of supply: responsibility for fuel storages in order (power companies or the fuel supplier), but responsibility for security for sufficient generation capacity is not defined. The office of national security of supply (for all commodities and services) office of ministry of trade and industry is working with the issue in co-operation with the power sector
ECONOMIC COMPARISON OF POWER PLANTS

• Based on the calculations made in the beginning of 2002 (price level 11/2001)
• Updated calculations are shown at the end of this presentation (the highlights of the results have remained the same)
• ”Own-cost” generation cost of electricity without profit or taxes on business profit is calculated
• Suitable for comparison between the power plants
• The profitability of the investment should be assessed based on the future market price of electricity and the ”own-cost” generation cost
POWER PLANT ALTERNATIVES (slide 1)

- CHP (COGENERATION) IS APPLIED AS MUCH AS POSSIBLE IN FINLAND FOR DISTRICT HEATING AND FOR INDUSTRIAL PROCESS HEAT. USUALLY CHP PLANTS ARE MORE ECONOMICAL THAN CONDENSING POWER PLANTS AND ALL APPROPRIATE CHP PLANTS ARE REALISED. THE AVAILABLE HEAT LOADS FOR CHP PLANTS IS A CONSTRAINT

- IN THIS STUDY MERELY ELECTRICITY PRODUCING ALTERNATIVES ARE STUDIED


- THE POWER PLANT ALTERNATIVES ARE:
  - NUCLEAR POWER PLANT 1250 MW
  - COMBINED CYCLE GAS TURBINE PLANT 400 MW
  - COAL-FIRED CONDENSING POWER PLANT 500 MW
  - PEAT-FIRED CONDENSING POWER PLANT 150 MW
  - WOOD-FIRED CONDENSING POWER PLANT 50 MW
  - WIND POWER PLANT 1 MW
POWER PLANT ALTERNATIVES (slide 2)

NUCLEAR POWER PLANT 1250 MW

- The sizing of the nuclear alternative is selected in the middle of the range of the reactors under consideration. The investment and operation costs of the nuclear unit are based on the fact that it would be built on an existing nuclear site.

- The construction time of the nuclear power plant is supposed to be five years. All the expenses of nuclear waste treatment (including spent fuel) and decommissioning of the plant are included in the operation and maintenance costs through the annual payments to the nuclear waste fund.

- The initial fuel loading is included in the investment cost.
POWER PLANT ALTERNATIVES (slide 3)

COAL-FIRED CONDENSING POWER PLANT 500 MW
- The existing Meri-Pori power plant with pulverised coal combustion has been used as the reference unit for the coal-fired power plant.
- The coal plant would be located on the seacoast.

COMBINED CYCLE GAS TURBINE PLANT 400 MW
- The performance and cost data of the combined cycle gas turbine plant is based on new efficient concepts now available internationally.

PEAT-FIRED CONDENSING POWER PLANT 150 MW
- The existing Haapavesi power plant with fluidised bed combustion has been used as the reference unit for the peat-fired power plant.
- The size of the peat plant is restricted to 150 MW, because the transport distance of peat fuel is growing too long for bigger unit sizes.
POWER PLANT ALTERNATIVES (slide 4)

WOOD-FIRED CONDENSING POWER PLANT 50 MW
- The fuel is wood chips made of forest residuals after harvesting the raw material for forest industry.
- The wood-fired unit is also based on fluidised bed combustion.
- The size of the wood plant is restricted to 50 MW, because the transport distance of wood fuel is growing too long for bigger unit sizes.
- Generation cost is calculated without government investment subsidy and refunding of the electricity tax.

WIND POWER PLANT 8 x 1 MW
- The existing Meri-Pori wind park has been used as the reference plant.
- Generation cost is calculated without government investment subsidy and refunding of the electricity tax.
LOAD DURATION CURVE OF FINNISH POWER SYSTEM
SCHEMATIC PRESENTATION

Electricity supply in 2010:
90 TWh
Peak load = 15 000 MW
Peak load utilization time = 6000 h corresponding to a load factor of 68.5 %
CALCULATION OF ELECTRICITY GENERATION COSTS

- COST PRICE (PRODUCTION COST) OF ELECTRICITY IS CALCULATED
- ANNUITY METHOD (THE RECOVERY OF THE INVESTED CAPITAL WILL TAKE PLACE AS EQUAL ANNUAL PAYMENTS DURING THE ECONOMIC LIFETIME OF INVESTMENT)
- FIXED PRICE LEVEL OF NOVEMBER 2001
- REAL INTEREST RATE
- ECONOMIC LIFETIME FOR NUCLEAR POWER PLANT IS 40 YEARS (TECHNICAL LIFETIME 60 YEARS), FOR THE OTHER PLANT TYPES LIFETIME IS SHORTER
- ANNUAL FULL-LOAD TIME OF 8000 HOURS IS USED CORRESPONDING TO CAPACITY FACTOR OF 91 %
- THE INTEREST DURING CONSTRUCTION IS INCLUDED IN THE INVESTMENT COST
DEREGULATION (LIBERALIZATION) OF THE POWER MARKET IN THE NORDIC COUNTRIES

- THE NORDIC ELECTRICITY EXCHANGE, NORDPOOL
- FINLAND, SWEDEN, NORWAY, DENMARK
- THE AVERAGE SPOT PRICE IN THE NORDIC ELECTRICITY EXCHANGE, NORDPOOL, IN YEARS 2000 AND 2001 HAS BEEN PRESENTED AS A REFERENCE FOR COMPARISON
- DUE TO ABUNDANT RAINFALL, THE SPOT PRICE HAS BEEN (2000 and 2001) VERY LOW
- NO NEW POWER PLANT PRODUCING ONLY ELECTRICITY HAS BEEN FINANCIALLY FEASIBLE WITH THE RECENT (1998-2001) ELECTRICITY MARKET PRICES
CHOICE OF THE REAL INTEREST RATE

- **BASE CASE**: 5% REAL INTEREST RATE
- **IN CASE OF AN INFLATION RATE OF 2 PER CENT PER ANNUM**, the real interest rate of 5 per cent corresponds to a nominal interest rate of 7.1 per cent per annum.
- **THE CALCULATIONS ARE CARRIED OUT ALSO WITH A REAL INTEREST RATE OF 8 PER CENT PER ANNUM**. It corresponds to a nominal interest rate of 10.2 per cent per annum, if the inflation rate equals to 2 per cent per annum.
ANNUITY METHOD

\[ A = AF(i, n) \times I \]

\[ A = \frac{i}{1 - (1 + i)^{-n}} \times I \]

WHERE

I = INVESTMENT
A = EQUAL ANNUAL PAYMENT (EQUAL-PAYMENT SERIES) = ANNUITY
i = INTEREST RATE
n = ECONOMIC LIFETIME OF THE INVESTMENT
AF(i, n) = ANNUITY FACTOR FOR PERIOD OF n YEARS AND ANNUAL INTEREST RATE OF i

\[ AF(i, n) = \frac{i}{1 - (1 + i)^{-n}} \]
ANNUITY METHOD; n = 25 years, i = 5 %

A = Annuity = Equal annual payment

40 years for nuclear
25 years for CCGT
25 years for coal

<table>
<thead>
<tr>
<th>i</th>
<th>n</th>
<th>AF(n,i)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 %</td>
<td>25 a</td>
<td>7.095 %</td>
</tr>
<tr>
<td>5 %</td>
<td>40 a</td>
<td>5.828 %</td>
</tr>
<tr>
<td>8 %</td>
<td>25 a</td>
<td>9.368 %</td>
</tr>
<tr>
<td>8 %</td>
<td>40 a</td>
<td>8.386 %</td>
</tr>
</tbody>
</table>

30.5  (coal fired power plant) Investment

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REAL INTEREST RATE

\[ 1 + r = \frac{1 + i}{1 + f} \quad ; \quad r = \frac{i - f}{1 + f} \]

Where
- \( r \) = real interest rate
- \( i \) = nominal interest rate
- \( f \) = inflation

<table>
<thead>
<tr>
<th>INFLATION, ( f )</th>
<th>REAL INTEREST RATE, ( r )</th>
<th>NOMINAL INTEREST RATE, ( i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 %</td>
<td>5 %</td>
<td>7.1 %</td>
</tr>
<tr>
<td>3 %</td>
<td>5 %</td>
<td>8.15 %</td>
</tr>
<tr>
<td>2 %</td>
<td>8 %</td>
<td>10.16 %</td>
</tr>
<tr>
<td>3 %</td>
<td>8 %</td>
<td>11.24 %</td>
</tr>
</tbody>
</table>
## PERFORMANCE AND COST DATA OF THE POWER PLANTS

<table>
<thead>
<tr>
<th>Performance and cost data</th>
<th>Nuclear</th>
<th>Coal</th>
<th>Peat</th>
<th>Gas</th>
<th>Wind</th>
<th>Wood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric power [MW]</td>
<td>1250</td>
<td>500</td>
<td>150</td>
<td>400</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Net efficiency rate [%]</td>
<td>35%</td>
<td>41%</td>
<td>38%</td>
<td>57%</td>
<td>-</td>
<td>38%</td>
</tr>
<tr>
<td>Investment cost [million euros]</td>
<td>2375</td>
<td>430</td>
<td>153</td>
<td>240</td>
<td>1.10</td>
<td>65</td>
</tr>
<tr>
<td><strong>Investment cost per power output capacity [euro/kW]</strong></td>
<td>1900</td>
<td>860</td>
<td>1020</td>
<td>600</td>
<td>1100</td>
<td>1300</td>
</tr>
<tr>
<td>Fuel price [euro/MWh]</td>
<td>1.06</td>
<td>7.00</td>
<td>6.00</td>
<td>13.50</td>
<td>-</td>
<td>7.00</td>
</tr>
<tr>
<td><strong>Fuel costs of electricity production [euro/MWh]</strong></td>
<td>3.0</td>
<td>17.1</td>
<td>15.8</td>
<td>23.7</td>
<td>-</td>
<td>18.4</td>
</tr>
<tr>
<td>Annual fixed operation and maintenance costs [percentage of investment]</td>
<td>1.5 %</td>
<td>2.0 %</td>
<td>2.5 %</td>
<td>1.5 %</td>
<td>2.0 %</td>
<td>3.0 %</td>
</tr>
<tr>
<td>Variable operation and maintenance costs [euro/MWh]</td>
<td>3.63</td>
<td>5.24</td>
<td>3.29</td>
<td>0.33</td>
<td>-</td>
<td>3.29</td>
</tr>
<tr>
<td>Economic lifetime [a]</td>
<td>40</td>
<td>25</td>
<td>20</td>
<td>25</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Real interest rate [%]</td>
<td>5.0 %</td>
<td>5.0 %</td>
<td>5.0 %</td>
<td>5.0 %</td>
<td>5.0 %</td>
<td>5.0 %</td>
</tr>
<tr>
<td>Annuity factor [%]</td>
<td>5.83%</td>
<td>7.10%</td>
<td>8.02%</td>
<td>7.10%</td>
<td>8.02%</td>
<td>8.02%</td>
</tr>
</tbody>
</table>
ELECTRICITY GENERATION COSTS
5 % REAL INTEREST RATE

Real interest rate = 5.0 %
November 2001 prices

Operation hours = 8000
hours/year

Wind Operation
hours = 2200 h/a

Generation costs without investment
grant and electricity tax rebate
SENSITIVITY ANALYSIS

THE IMPACT OF CHANGES IN THE INPUT DATA ON ELECTRICITY GENERATION COSTS

- THE CHANGE OF ANNUAL FULL-CAPACITY OPERATING HOURS
- THE CHANGE OF INVESTMENT COSTS
- THE CHANGE OF FUEL COSTS
- THE CHANGE OF REAL INTEREST RATE
- THE CHANGE OF ECONOMIC LIFETIME
ELECTRICITY GENERATION COSTS AS FUNCTION OF THE ANNUAL FULL-CAPACITY OPERATING HOURS
THE IMPACT OF INVESTMENT COSTS ON ELECTRICITY GENERATION COSTS

![Chart showing the impact of investment costs on electricity generation costs for nuclear, coal, and gas. The x-axis represents the change in investment cost from -20% to 20%, and the y-axis represents the cost in euros per MWh. The lines indicate the cost increase for each energy source as investment costs change.]
THE IMPACT OF FUEL COSTS ON ELECTRICITY GENERATION COSTS

Change in fuel costs: %

-25% 0% 25% 50%

Nuclear
Coal
Gas

euro / MWh
THE IMPACT OF REAL INTEREST RATE CHANGES ON ELECTRICITY GENERATION COSTS

![Graph showing the impact of real interest rate changes on electricity generation costs for different energy sources: Nuclear, Coal, and Gas. The x-axis represents the real interest rate (%), and the y-axis represents the cost in euros per MWh. The graph shows that as the real interest rate increases, the generation costs for all energy sources increase linearly.]
THE IMPACT OF ECONOMIC LIFETIME ON ELECTRICITY GENERATION COSTS, 5 % REAL INTEREST RATE

<table>
<thead>
<tr>
<th>Economic lifetime [years]</th>
<th>ELECTRICITY GENERATION COST [euro/MWh]</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nuclear power plant</td>
<td>Coal-fired condensing power plant</td>
<td>Combined cycle gas turbine plant</td>
</tr>
<tr>
<td>60</td>
<td>22.77</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>40</td>
<td>24.06</td>
<td>(30.7)</td>
<td>(29.5)</td>
</tr>
<tr>
<td>30</td>
<td>25.67</td>
<td>31.46</td>
<td>30.02</td>
</tr>
<tr>
<td>25</td>
<td>27.07</td>
<td>32.09</td>
<td>30.46</td>
</tr>
<tr>
<td>20</td>
<td>(29.3)</td>
<td>33.09</td>
<td>31.16</td>
</tr>
</tbody>
</table>
ELECTRICITY GENERATION COSTS
8% REAL INTEREST RATE

Fuel costs
O&M costs
Capital costs

operation hours = 8000 hours/year
Real interest rate = 8.0%
November 2001 prices
R Tarjanne & K Luostarinen 12.2.2002
Generation costs without investment grant and electricity tax rebate
SUMMARY OF THE ECONOMIC COMPARISON

- **NUCLEAR HAS LOWEST EL.GENER.COSTS, 24 €/MWh**
- **SENSITIVITY ANALYSIS STRENGTHENS THE COMPETITIVENESS OF NUCLEAR POWER**
- **NUCLEAR INSENSITIVE FOR CHANGES OF FUEL COSTS**
- **GAS EL. HIGHLY SENSITIVE FOR GAS PRICE CHANGES**
- **THE LONG DURATION PROFILE OF OF THE FINNISH POWER SYSTEM ENHANCES HIGH LOAD FACTOR FOR NUCLEAR, 91% (8000 h PEAK UTILIZATION TIME)**
- **NUCLEAR WILL QUARANTEE LOW STABLE ELECTRICITY PRICE FOR THE INDUSTRY**
- **NUCLEAR WILL BE HIGHLY PROFITABLE, IF THE AVERAGE MARKET PRICE OF ELECTRICITY IS 30-35 €/MWh**
- **CURRENTLY (AND PRESUMABLY ALSO IN THE FUTURE) THE REAL INTEREST RATES ARE VERY LOW. THIS MAKES CAPITAL INTENSIVE NUCLEAR STILL MORE ATTRACTIVE**
PUBLIC AND POLITICAL DISCUSSION
MAIN TOPICS (1/2)

- ELECTRICITY DEMAND FORECAST (THE "OFFICIAL" FORECAST WAS TOO LOW!)
- COST AND COMPETITIVENESS OF NUCLEAR POWER: IN FINLAND; COMPARISONS WITH OTHER COUNTRIES
- IN THE BEGINNING: NUCLEAR WAS BLAMED SO EXPENSIVE THAT THE PENSION MONEY FOR "GRANDMOTHERS" IS LOST (AS SUCH THE ARGUMENT IS WRONG, BECAUSE GOVERNMENT DO NOT PAY ANYTHING!)
PUBLIC AND POLITICAL DISCUSSION
MAIN TOPICS (2/2)

• AT THE END: NUCLEAR WAS BLAMED SO CHEAP THAT THE OPPORTUNITIES OF THE RENEWABLES WILL DISAPPEAR!
• THE LIBERALIZED NORDIC POWER MARKET
• THE IMPACT OF EMISSION TRADING
• POSSIBILITIES TO MEET THE KYOTO COMMITMENTS
• SECURITY OF SUPPLY (THE GREAT SHARE OF ENERGY IMPORTS)
• POTENTIAL OF ENERGY SAVING
• INTERNATIONAL COMPARISONS ON THE EFFICIENCY AND EMISSION INDICATORS OF ENERGY SUPPLY
• THE IMPACT OF KYOTO COMMITMENTS ON THE NATIONAL ECONOMY (GDP GROWTH RATE) IN THE DIFFERENT GENERATION ALTERNATIVES (MORE NUCLEAR, MORE GAS, MORE BIOENERGY AND WIND, MORE ENERGY TAXES & COMBINATIONS, ETC.)
• DISPOSAL OF NUCLEAR WASTE AND NUCLEAR ACCIDENTS
CARBON DIOXIDE EMISSION TRADING

• IN EU 2005 – 2007 ! (?)
• KYOTO PROTOCOL 2008 – 2012 (?)
• COST OF CO2 TON UNKNOWN – IN THE RANGE OF 5-100 €/TON CO2
• IMPACT ON ”EFFECTIVE” FUEL PRICE
• IMPACT ON THE MARKET PRICE OF ELECTRICITY
• NEW POWER PLANT COMPARISON CALCULATIONS WITH THE PRICE LEVEL OF MARCH 2004 AND THE EMISSION COST OF 20 €/TON CO2
• THE EMISSION TRADING WILL IMPROVE CONSIDERABLY THE PROFITABILITY OF NUCLEAR
PERFORMANCE AND COST DATA OF THE POWER PLANTS, March 2004 prices

<table>
<thead>
<tr>
<th>INPUT DATA</th>
<th>March 2004 prices</th>
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<td>Peat</td>
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<td>Wood</td>
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<td>Annuity factor [%]</td>
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<td>Wind</td>
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ELECTRICITY GENERATION COSTS WITHOUT EMISSION TRADING

ELECTRICITY GENERATION COSTS, WITHOUT EMISSION TRADING

Fuel costs
O&M costs
Capital costs

Real interest rate
March 2004

Operating hours 8000
R. Tarjanne & K. Luostarinen

Generation costs without investment subsidy and the return of electricity tax (wood)

Operating hours 2200

22.6.2004 R. Tarjanne, LUT
FUEL PRICE & EMISSION PRICE, IF 20 €/TON CO2

€/MWh

FUEL

NUCLEAR GAS COAL PEAT WOOD WIND

EMISSION PRICE
FUEL PRICE

22.6.2004 R. Tarjanne, LUT
ELECTRICITY GENERATION COSTS WITH EMISSION TRADING 20 €/tCO2

ELECTRICITY GENERATION COSTS, WITH EMISSION TRADING

- Emission trade 20 €/t CO2
- Fuel costs
- O&M costs
- Capital costs

Operating hours

Real interest
March

Generation costs without investment subsidy and the return of electricity tax (wood and wind)

R. Tarjanne, LUT

22.6.2004
ELECTRICITY SUPPLY BY ENERGY SOURCES

YEAR 2002, TOTAL 83.9 TWh

- NUCLEAR: 21.5 TWh
- HYDRO: 10.7 TWh
- WOOD: 10.5 TWh
- WIND: 0.1 TWh
- GAS: 9.2 TWh
- COAL: 12.1 TWh
- PEAT: 6.1 TWh
- OIL: 1.8 TWh
- IMPORTS: 11.9 TWh

February 2003  R.Tarjanne, K. Luostarinen
ARGUMENTS FOR THE NEW NPP AND CONCLUSIONS

- As NPP has the lowest gen. costs and zero CO2 emissions, it is the best (and highly necessary) choice for Finland to meet the Kyoto commitments.
- Nuclear will improve security of energy supply and guarantee availability of cheap electricity.
- The emission trading still improves the profitability of nuclear.
- The new NPP (1600 MW - 13 TWh/a) will save 11 million tons CO2 emissions annually.
- Increase of nuclear power is the logical consequence of Kyoto Protocol (the purpose of which isto cut down CO2 emissions).
- The other CO2 free choices are also needed, but their potential is limited and electricity generation costs higher.
- Gas based power generation should be increased, if it is competitive.
- Based on the projected demand of electricity, the GHG emissions seem to exceed the Kyoto commitment in the 2010's in spite of the fifth nuclear unit to be commissioned in 2009.
- One more (the sixth one) nuclear unit would be needed in the near future!