Finnish EPR Olkiluoto 3

The world's first third-generation reactor now under construction

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AREVA

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The EPR in the Finnish context

The Finnish situation

The Finnish government's energy policy is to "secure a competitive energy supply while at the same time meeting the obligations associated with its international environmental commitments."[1]

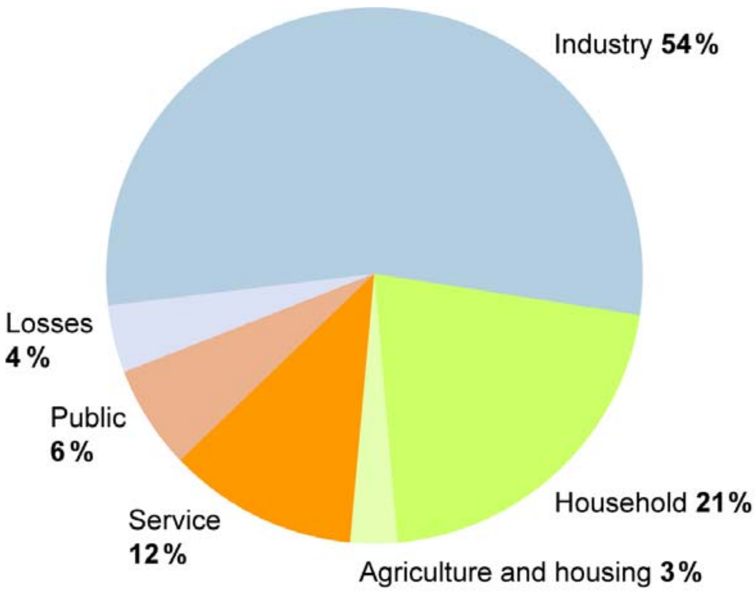
> Electricity consumption

Finland used almost 90 terawatt hours (TWh) of electricity in 2006. According to the Energy Year 2006 data published by Finnish Energy Industries, the increase in electricity consumption adjusted for temperature and calendar was 5.6 percent.[2]

According to the most recent scenario by the Finnish Ministry of Trade and Industry, the consumption of electricity is expected to evolve from the 2000 level of 79.2 TWh to 94.2 TWh in 2010 and further to 103.3 TWh in 2020.

Industry and construction are the largest consumers of electricity because Finland has an energy-intensive industry. **In 2006, Finnish industries used about 54% of all electricity[3].**

Electricity consumption in 2006, 89.991 GWh in total



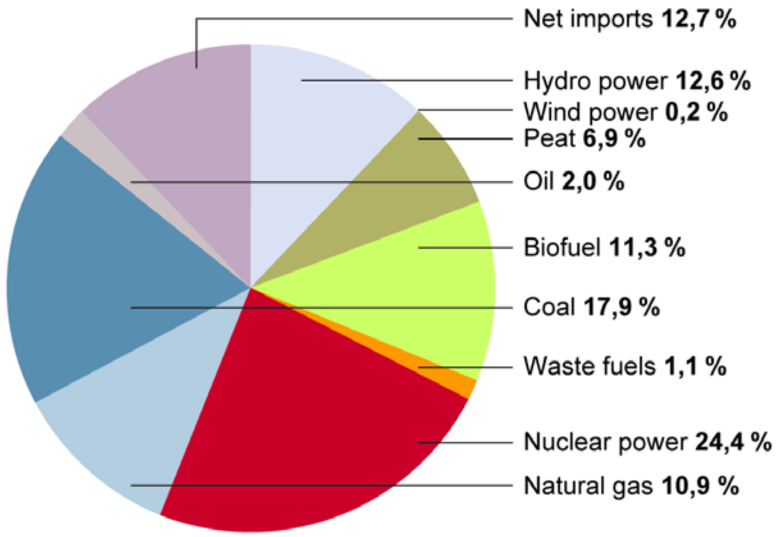
Source: Finnish Energy Industries (2007)

Electricity supply

Finland has no coal, oil, or natural gas deposits. It is poor in terms of indigenous energy reserves like hydropower. As a result, the country imports 44% of its energy sources[4].

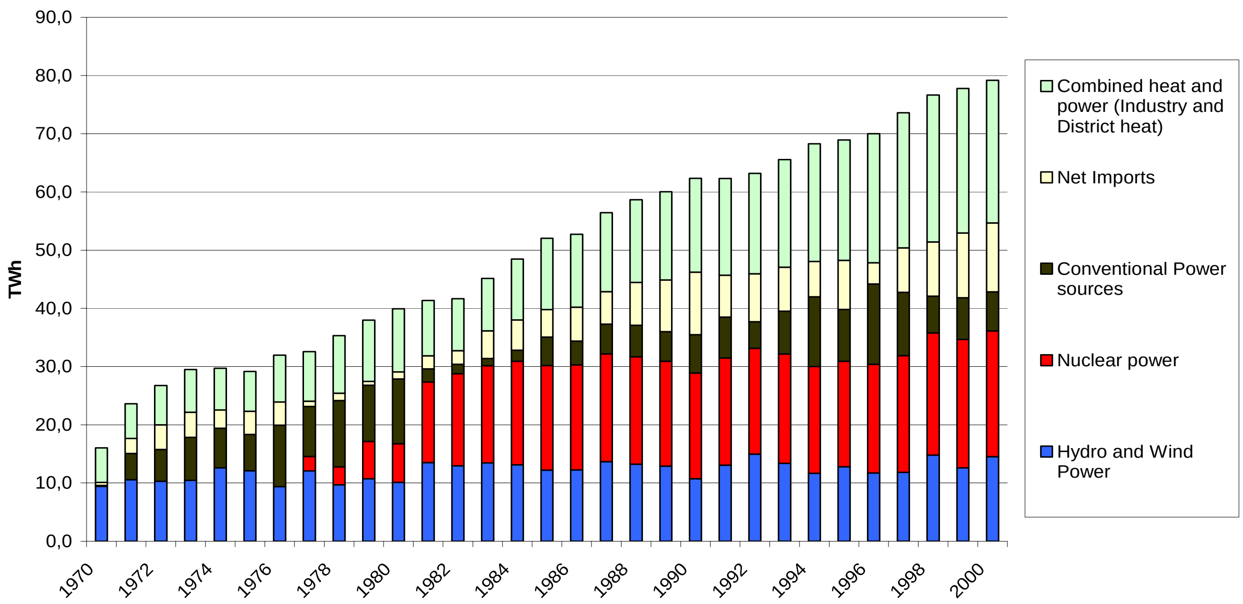
A considerable amount of new electricity production capacity is needed to meet the increased power demand and to compensate for the decommissioning of older plants. Increase in production of combined heat and power covers part of the rising demand, but is not enough. In practice, the climate commitments made by Finland exclude the extension of coal power[5].

Electricity Supply in 2006



Source: Finnish Energy Industries (2006)

Supply of Electricity



Source: Finstat (2005)

The crucial role of nuclear energy in Finland today

Nuclear energy is more important than any other energy source and accounts for 24% of electric power generation.

- Finland has four nuclear power reactors with a total net generating capacity of 2696 MW. All four units went into commercial operation between 1977 and 1982.
- Olkiluoto site has two 860 MWe boiling water reactors, which are operated by the Finnish utility Teollisuuden Voima Oy (TVO), originally built by ASEA-Atom (later ABB, today part of the Westinghouse Group).
- At the site of Loviisa, two 488 MWe Russian VVER design reactors are operated by the Finnish company Fortum Power and Heat Oy.

The final disposal of low and intermediate level waste (LLW and ILW) has already been solved in Finland. In Olkiluoto (operational since 1992) and Loviisa (operational since 1997), the LLW and ILW is emplaced in final repositories inside the power plant area, where silos have been excavated in the bedrock at a depth of 70-100 meters.

The spent nuclear fuel from Finnish nuclear power plants (high level waste, HLW) is intended to be disposed of at a final disposal to be built in Olkiluoto. After intensive site investigations, the Finnish nuclear waste management company Posiva Oy, owned by TVO and Fortum Power and Heat Oy, proposed Eurajoki in 1999 – the municipality of the Olkiluoto plant – as the site for a final repository for HLW. Meanwhile, Government and Parliament have given a green light for the site investigation in Olkiluoto. Also, the municipality of Eurajoki supports construction of a HLW repository. Currently, Posiva Oy, is building an underground research facility (Onkalo) at the final disposal site. The premises will allow supplementary bedrock studies. Disposal is scheduled to start in 2020.

> Finland's Kyoto CO_2 cutback

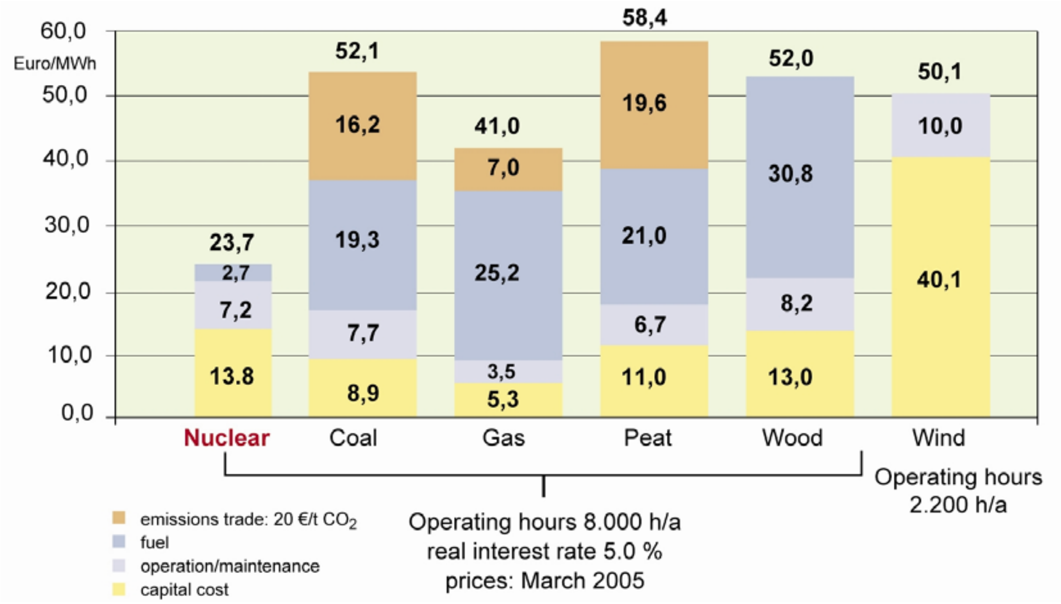
Finland and the EU ratified the Kyoto Protocol in 2002. Under the Kyoto Protocol and the EU's burden sharing agreement, Finland is committed to limiting its average greenhouse gas emissions for the years 2008-2012 to the 1990 level.

The Government expects the new nuclear power plant, along with energy conservation programs that will increase the use of renewable energy sources, to help maintain greenhouse gas emissions at the 1990 level[6].

> Competitiveness of nuclear power

According to a study by the University of Technology in Lappeenranta, the long-term average generating cost of nuclear electricity is lower than that of electricity produced by coal or gas with a full load utilization time of 8000 hours per year – corresponding to a load factor of about 90%. Electricity generation cost assessments were based on a 5% real interest rate, a 40-year economic lifetime for nuclear plants with a 25-year lifetime for both coal and gas-fired power plants. The study, which is updated regularly, indicates that nuclear electricity maintains its position as the lowest-cost generating method even when the real interest rate is varied up to 10% per year.

Electricity generation costs including emission trading*



Source: Tarjanne, Risto; Luostarinen, Kari (2005): Competitiveness comparison of the electricity production alternatives

This increasing dependency on electricity imports led the Finnish Parliament to ratify the construction of a fifth nuclear power unit on May 24, 2002. This ratification was based on the view that the nuclear option is the best alternative in terms of cost-effectiveness, security of electricity supply, and environment and climate compatibility within the framework of the Kyoto Protocol. This decision was made following a national and regional public debate.

The EPR becomes reality in Olkiluoto

> General schedule of responsibilities

On December 18, 2003, the consortium formed by AREVA and Siemens – and led by AREVA – signed a contract with TVO for the turnkey construction of the EPR. The overall Olkiluoto 3 project cost has been estimated by TVO at around € 3 Billion.

According to the contract terms, AREVA NP's scope of work includes the following: supplying the nuclear island (NI), the digital control system, and the first fuel core, civil works, parts of balance of plant comprising the access building, waste building, and an EPR simulator. AREVA NP, as leader of the consortium, coordinates the overall project including functional and technical integration of the complete plant.

Siemens PG will build the turbine island (TI) and supply the turbine generator set that includes engineering and design, procurement and delivery of electro-mechanical equipment, turbo-generator protection and control system, civil works, erection, and commissioning.

A significant part of the civil construction and erection work has already been subcontracted. A large amount (42%) was awarded to companies in Finland directly, but companies from abroad often engage Finnish sub-suppliers, too.

TVO is responsible for the overall project management and licensing process with the Finnish Safety Authority STUK. In the prequalification phase, STUK concluded that the EPR can meet the Finnish licensing requirements. All specific comments will be taken into account for the realization of the project. In January 2005, STUK emphasized in its safety assessment that the evolutionary EPR design compared to predecessor product lines has been further enhanced by AREVA.

> Important milestones of the project

18 December 2003	Signature of the OL 3 construction contract
1 January 2004	Contract enters into force
14 January 2005	The responsible municipality of Eurajoki issues the building permit for the OL 3 nuclear power plant
21 January 2005	The Finnish Radiation and Nuclear Safety Authority STUK submits the requisite – and positive – statement of position and safety evaluation pursuant to nuclear licensing to the Finnish Ministry of Trade and Industry
26 January 2005	Starts manufacturing Reactor Pressure Vessel

Manufacturing of the pressure vessel

1 February 2005	AREVA and Siemens consortium partners take over construction site from TVO
17 February 2005	The Finnish Government issues to TVO the nuclear construction license for the OL 3 nuclear reactor
February 2005	Starts of construction work for the reactor building complex
May 2005	Starts of construction work for the Turbine Hall
15 July 2005	Arrival of the metallic liner (bottom part) for the inside wall of the reactor building

12 September 2005	Laying the foundation stone

Paavo Lipponen, Speaker of the Finnish Parliament, at the ceremony.

October 2005	Concreting the base slab for the reactor building
11 May 2006	Positioning the bottom part of the metallic liner on the base slab

The installation process using one of the world’s largest heavy-load cranes took about 8 hours.

14 July 2006	First hydrostatic test in the turbine island

A hydrostatic test is one way a pressure pipe system is checked for leaks. The system is filled with water, pressurized, and then examined for leaks or permanent changes in shape.

Primary components manufacturing in progress (Châlon St. Marcel)

September 2004 to November 2006

Steam Generator Lower Pressure Boundary Subassembly

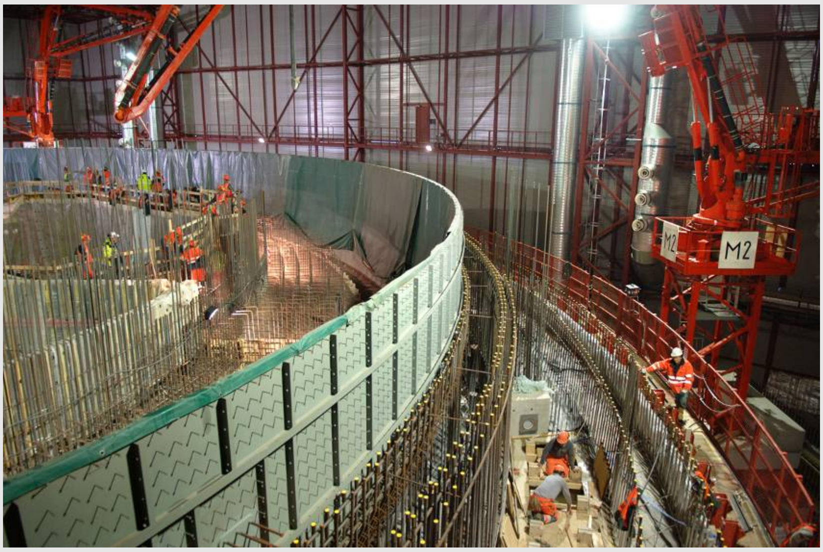
19 October 2006

Casting completed for inner slab of reactor building

Over 2000 m3 of concrete was poured, and the final thickness of new slab is now 1.5 metres.

15 February 2007

Concrete pouring accomplished



Approx. 3700 m3 of concrete was used for both sides of the liner. This was an even larger pour than the base slab.

April 2007 (ongoing) Reinforcing works for the concreting of the turbine table


Turbine building next to the reactor building

> Next steps in 2007

Spring 07

- Reinforcing and pouring of the inner containment wall foundations
- Installing the reinforcement for the outer shell that is designed to withstand air plane crashes (APC shell)

Summer 07

- Lifting the first vertical elements of the steel containment liner
- Beginning erection of the condenser (turbine island)

Autumn 07

- Installing first auxiliary equipment (tank)
- Beginning erection of the steam turbine and the generator

> Industry in Finland and abroad benefits from the OL 3 Project

- Today, the total manpower at the site is approximately 1200 persons. During peak times, 3000 people may be working on site.

- Presently, 1500 subcontracts have been awarded to suppliers from 27 countries. A significant amount (42%) was awarded directly to companies in Finland, but companies from abroad often engage Finnish subsuppliers, too.

The EPR advanced nuclear reactor

EPR: Optimizing skills in Europe

> Targeted design objectives

The EPR was developed by Framatome and Siemens KWU (the nuclear division of Siemens), whose nuclear activities were combined in January 2001 to form Framatome ANP, now AREVA NP. The French electricity utility EDF (Electricité de France), together with the major German utilities, played an active role in the project. The safety authorities of the two countries joined forces to bring their respective safety standards into line and draw up joint design rules for the new reactor.

The project had three objectives:

- Comply with the safety standards laid down by both the French and German safety authorities for future pressurized water reactors.
- Meet the "European Utility Requirements." This specification was drawn up by electricity companies in Belgium, Finland, France, Germany, Great Britain, Italy, Holland, Spain, Sweden, and Switzerland. The "European Utility Requirements" also make allowance for the specifications of operators in the United States, drawn up under the aegis of the Electric Power Research Institute (EPRI).
- Generate electricity cheaper than that generated in the most recent reactors in operation.

> Main characteristics

- The EPR is a pressurized water reactor based on the most recent technologies: the French N4 reactors in operation at Chooz and Civaux Nuclear Power Plants, and the Konvoi reactors in operation at Neckarwestheim 2, Emsland, and Isar 2 in Germany. The EPR benefits from over thirty years operating feedback from nuclear power plants. AREVA has built more than 90 nuclear reactors, representing almost 30% of the total installed nuclear power capacity worldwide.
- The EPR is an evolutionary product**.** It is based on pressurized water reactor technology that is currently the most widely used with 264 reactors in operation out of a total of 435. Pressurized water reactors account for 56% of the total installed capacity worldwide.
- As a new-generation reactor, the EPR affords significant economic and technical progress: enhanced safety level, reduced volumes of long-lived waste, considerable reduction in the doses received by operating and maintenance personnel, and

reduced electricity production costs (better use of fuel, improved availability, higher operating flexibility, and fewer maintenance constraints).

An even more competitive reactor

With the EPR, it will be possible to generate electricity at an even lower cost than that of electricity generated in most recent reactors. The savings will be made thanks to the optimization of a number of major factors:

- The electrical power of the EPR (around 1600 MWe) is higher than that of the most recent plants (around 1450 MWe).
- The service life of the EPR has been extended to 60 years rather than 40 years for the previous reactors.
- Better use is made of fuel. With the EPR, 17% less uranium is required to generate the same amount of electricity, thereby, reducing the volume of waste. Costs are, therefore, lower for the entire fuel cycle from enrichment to reprocessing.
- The general layout of the equipment is designed to provide easier access and simplify maintenance operations that are consequently carried out more rapidly. Routine maintenance of safety-related systems can be carried out without shutting down the plant.
- The length of the scheduled refueling outage has been shortened to allow an increase of reactor availability – over 90%.

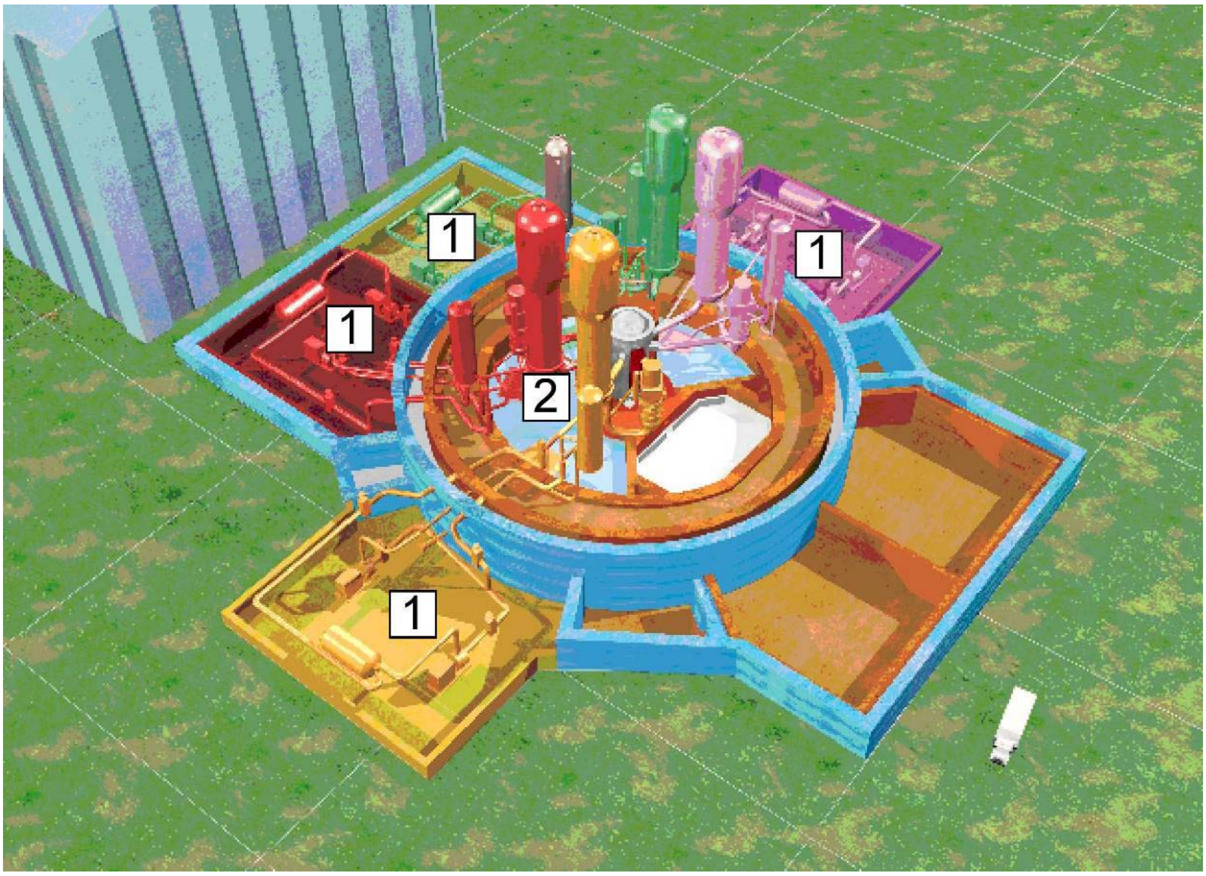
With the EPR, the cost of the electricity generated will be significantly lower than the cost of electricity generated using gas, the main rival energy source. Nuclear is the only electrical source, other than hydro, that incorporates in the kilowatt hour all the external costs for waste disposal and decommissioning.

An even higher level of safety

Safety in the nuclear industry is an integral part of continuous progress. Pressurized water reactors are extremely safe industrial facilities, and their high level of safety has been increased even further with the EPR.
After harmonizing their regulations, the French and German Safety Authorities laid down two requirements, as discussed below, both of which have been met:

> Additional measures to prevent the occurrence of events likely to damage the core

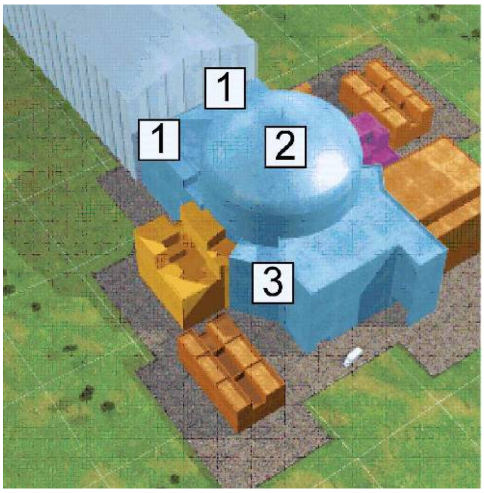
The safety functions are performed by a variety of simple, redundant systems. They are more highly automated.



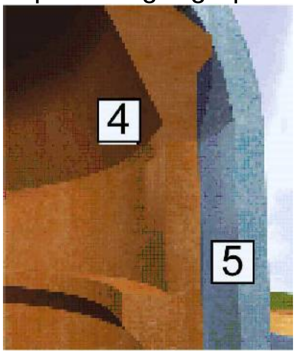
Each of the main safety systems is subdivided into four identical subsystems that perform the same function when an abnormal operating situation occurs, in particular to cool the core, thus ensuring that the safety function is always performed. The subsystems are totally independent and are kept strictly separate by being housed in four different buildings. Thus, whenever the slightest fault occurs in one system due to internal (flooding, fire, etc.) or external incidents, another system can take over and perform the necessary safety function.

In line with the requirements of the French and German safety authorities, the initial designs of the EPR made allowance for a **military aircraft impact scenario**. In the September 11 context, the call for bids launched in 2002 by Finland for its fifth reactor demanded that candidate models must be capable of **withstanding an impact by a commercial aircraft.** The EPR designs were, therefore, upgraded with extra thickness and provided scope for these modifications without any effect on the fundamental design of the EPR.

These improvements are now an integral part of the EPR model offered to all customers.



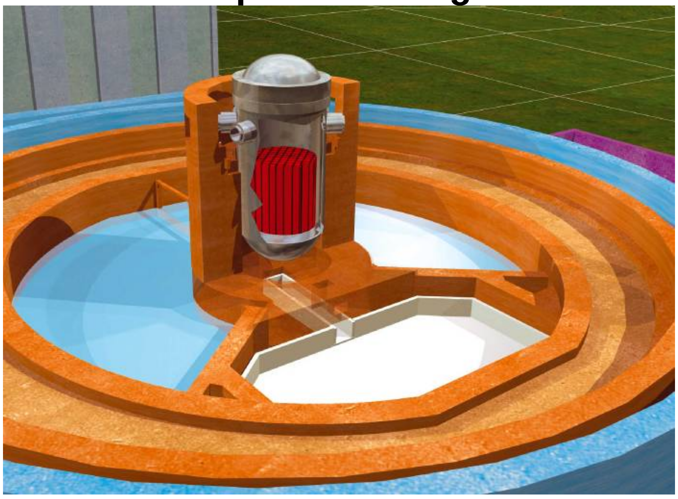
The outer shell (5) covers the reactor building (2), the spent fuel building (3) and two of the four safeguard buildings (1). The other two safeguard buildings are separated geographically.



The reactor containment building has two walls: an inner prestressed concrete housing (4) internal covered with a metallic liner and an outer shell (5) both more than 1 m thick.

The likelihood of core damage occurring in current pressurized water reactors is extremely remote; in addition, the EPR safety-system architecture reduces it even further. Thus, the EPR represents a new quality of safety.

> Increased protection against the consequences of core melt



In the highly unlikely event of core damage occurring, measures have been taken to protect the public and the environment from all possible consequences.

Even if a core melt should occur, the molten core (“corium”), after melting through the reactor vessel wall, would be contained in a dedicated spreading compartment.
This compartment is then cooled to remove the residual heat.

With the EPR, this type of extreme core melt would not extend beyond the reactor containment. The vicinity around the plant, the subsoil, and the water table would be fully protected.

The EPR in international competition

> France

- On October 21, 2004, EDF decided to go ahead with the construction of a first-of-a-kind EPR, with a rated power of around 1600 MW, at Flamanville in the Normandy region of France. On May 4, 2006, after a public debate, EDF's Board of Directors confirmed this decision. Excavation work on the EPR site started in the summer of 2006.

- During the summer, AREVA submitted a successful bid for the design and supply of the operational I&C, based on the TELEPERM XP system manufactured by Siemens PGL.

- On January 24, 2007, following the announcement by the EDF Board of Directors, AREVA was asked to supply the nuclear steam supply system for the Flamanville EPR. With this major agreement, the AREVA group gained its 100th reactor order.

- The contract includes engineering studies and the manufacture of all the reactor components – reactor vessel, reactor vessel head, steam generators, pumps, pressurizer, control rod drive mechanisms, etc. – most of which will be produced in AREVA's Chalon St Marcel and JSPM plants.

- Once the French Nuclear Safety Authority had approved the construction of the Flamanville EPR, the construction permit for the Flamanville-3 Basic Nuclear Installation, comprising an EPR reactor, was published in the Official Bulletin of April 11, 2007. This marked a major step in the administrative process.

- The EPR will contribute to the replacement of today's 58 nuclear power units (34 reactors of 900 MW, 20 reactors of 1.300 MW, and 4 reactors of 1450 MW). By 2020, the first reactors will be reaching 40 years' of operations. EDF intends to have a proven third-generation technology before launching a new series.

- In 2020, the annual demand for electricity (barring exports) will have increased by 33% assuming a realistic growth rate of 1.6% per year. It will be impossible for France to meet this requirement unless it has an additional production capacity of 18,000 MWe operated with a utilization rate of 90%. Energy savings and renewables alone will not be enough.

> United States

- On 15 September 2005, Constellation Energy and AREVA announced the formation of **UniStar Nuclear.** UniStar Nuclear will offer the business framework that will enable the development of joint ventures with Constellation Energy, other energy companies, and interested parties. These joint ventures, in turn, will license, construct, own, and operate nuclear power plants as part of a standardized fleet.

- UniStar Nuclear will market a standard advanced design called the U.S. Evolutionary Power Reactor **(U.S. EPR)**. This 1600 MW model is based on AREVA's advanced nuclear power plant, which is now being built in Finland and will also be built in France. AREVA has completed phase one of its U.S. EPR Design Certification (DC) pre-application process with the Nuclear Regulatory Commission Completing this initial review phase is a significant milestone that will help ensure completion of a high-quality DC application.

- It is expected that the DC application will be submitted by the end of 2007, with an anticipated validation by 2010. This would ensure that a U.S. EPR could be licensed and ready for operation in 2015.

- On April 5, 2007, UniStar Nuclear announced an agreement with Missouri-based utility AmerenUE to prepare a combined construction and operating license application. In order to deploy a standardized U.S. EPR fleet, UniStar Nuclear has added this agreement to its growing list of potential nuclear projects that are being considered for development across the U.S.

Endnotes and Sources

> Endnotes

(1) Finnish Government Program 2003

(2) Finnish Energy Industries (ENERGIATEOLLISUUS, former FINERGY), press releases: Energy Year 2007

(3) Finnish Ministry of Trade and Industry: Nuclear Energy in Finland

(4) Idem

(5) Finnish Ministry of Trade and Industry: Nuclear Energy in Finland

(6) Finnish Ministry of Environment, July 4, 2005

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Our 61,000 employees are committed to continuous improvement on a daily basis, making sustainable development the focal point of the group's industrial strategy.

AREVA's businesses help meet the 21st century's greatest challenges: making energy available to all, protecting the planet, and acting responsibly towards future generations.

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Published by and copyright (2007):
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Freyeslebenstrasse 1
91058 Erlangen, Germany
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Update: April 2007

AREVA