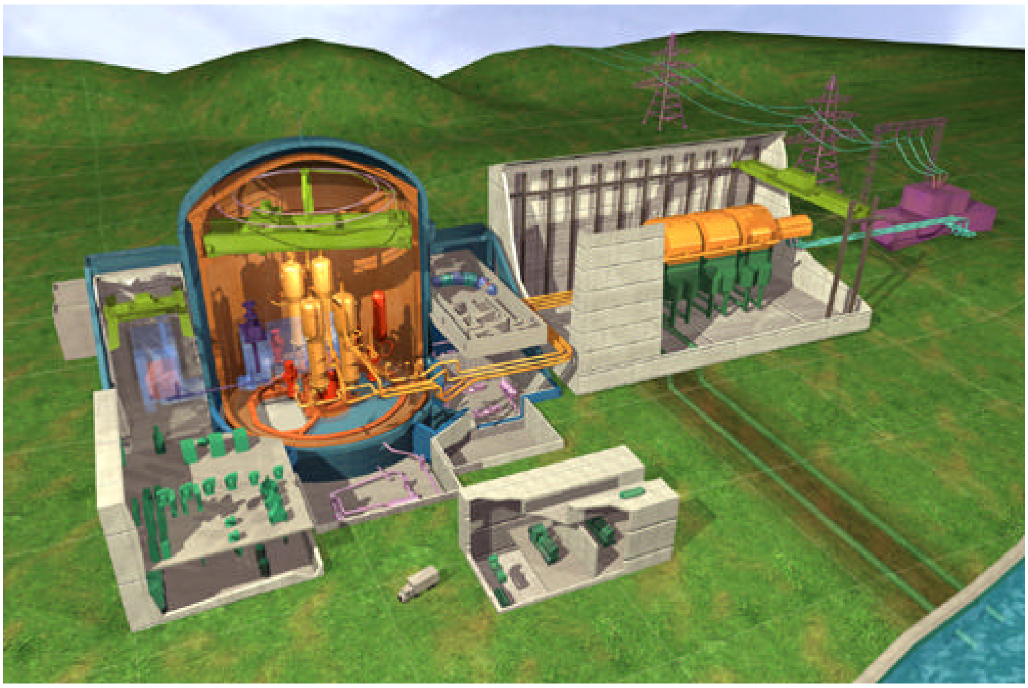
PRESS KIT

EPR

(European Pressurized water Reactor)

The advanced nuclear reactor



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AREVA

EPR, THE ADVANCED NUCLEAR REACTOR

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EPR: AN ADVANCED NUCLEAR REACTOR

NUCLEAR ENERGY – AN ASSET FOR THE ENERGY MIX

1 - INCREASING ENERGY NEEDS WORLDWIDE

By 2050, the Earth's population will have risen to between 8 and 10 billion, compared to today's figure of 6 billion, of whom almost 2 billion are still without electricity! Energy needs will increase considerably, since mankind will naturally aspire to improved living conditions and a more equitable sharing of the benefits of economic progress.
Intensive use of fossil fuels will not be the answer, since this would only contribute further to global warming. **Since it does not produce any greenhouse gases, nuclear energy will have a major role to play in the energy mix of the future, as will renewable energies.**

2 – THE COMPARATIVE ADVANTAGES OF NUCLEAR ENERGY

- Numerous studies[1] published between 1997 and 2002 illustrate that the production cost of electricity generated in nuclear power plants compares favorably with the cheapest form of electricity generated using fossil fuels in combined cycle gas plants.
  Even assuming that fuel prices will rise, this remains true:

  - A 10% variation in the cost of natural uranium results in a variation in cost of the MWh of less than 0.5 %[2].

  - Conversely, a 10% variation in the cost of gas results in a variation of more than 6%[3] in the cost of the electricity generated, a figure that is particularly significant since the price of gas could increase considerably if the markets come under strain in the future.

[1] DGEMP and OECD studies, parliamentary report published by Messrs Galley and Bataille, report produced for the Prime Minister by Messrs Charpin, Pellat and Dessus, Finnish study published by Messrs Rissanen and Tarjanne.
[2] Idem
[3] Idem

All the studies carried out in Europe consider the average discounted costs to be within the following ranges

Euro/MWh	Nuclear	Combined cycle gas
Total production cost	24 to 32	31 to 57
Cost of environmental impacts (ExternE* study)	2 to 7	10 to 40
Total	26 to 39	41 to 97

*The ExternE study was carried out by researchers from the United States and all the Member States of the European Union, with the support of the European Commission, to quantify the social and environmental costs associated with electricity generation.

- **The comparative advantages of nuclear energy** are even more striking if the impact of carbon emissions on the environment is considered from an economic point of view, as stipulated in the European directive on release permits, scheduled to come into force in 2005. The challenge is clearly enormous, given the orders of magnitude involved, with savings of hundred of millions of metric tonnes of CO_2 to be made for Europe alone.

- **Uranium, the raw material used to generate nuclear energy, is found in a number of countries, particularly politically stable ones** such as Canada, the United States and Australia. **Stocks are plentiful and will be even limitless** if reactor designs capable of increasing their energy potential more than 50-fold are adopted in the future. An extensive amount of research is being devoted to these designs in the framework of international cooperation agreements.

- **The decision to generate nuclear energy guarantees steering clear of a strategically vulnerable situation,** unlike oil and natural gas which are found, for the most part, in politically unstable regions. Moreover, far from being inexhaustible, these fossil fuels are likely to reach a production peak in the middle of this century, after which they will start dwindling again.

3 - THE BENEFITS OF NUCLEAR ENERGY

- The energy situation in the 1960s and 1970s prompted France to launch its nuclear energy program with a view to becoming self-sufficient. At the time, France imported 76% of its energy supplies, with oil accounting for 66% of its imports.

- Today, fifty-eight nuclear reactors are in service in France. In 2002, a total of 558.8 TWh, of electricity was generated, with 436.8 coming from nuclear power plants, i.e. more than 78%[4].

[4] DGEMP, 2002 provisional energy report for France.

France is now reaping the benefits of its nuclear energy program

- **In 1973, France was able to meet on its own 20% of its energy requirements. By 2001, this figure had risen to 50%.** France is therefore far less vulnerable to the wild fluctuations in oil and gas prices which are always reflected in the amounts to be paid by consumers.
- The French nuclear industry has come of age and counts more than 40 years' experience. France's expertise in pressurized water reactor technology is unrivalled. More than one hundred thousand people are employed in the nuclear industry, plus those employed indirectly. **Thanks to this technological advantage, AREVA is the world leader in the nuclear industry, with a growing export market, mainly to USA, Asia and Finland.**

- Year after year, the balance for electricity imports and exports, the sale of Nuclear Steam Supply Systems (NSSS) and nuclear fuel cycle services **is largely in surplus**. **Thus, in 2002, the three nuclear divisions of the AREVA Group –front end, reactors and services and back end – generated 54% of its revenues[5] outside France, and EDF exported 77 TWh[6] net of electricity.**

- Nuclear energy is clean because it does not produce any greenhouse gases. This is a major advantage for France as a signatory of the Kyoto protocol to reduce greenhouse gas emissions. **Thanks to its nuclear energy program, France has one of the lowest CO_2 release rates of all the OECD countries, coming second only to Sweden[7].**

CO_2 releases per inhabitant in 2002 (t/inhabitant)

Sweden	5.4
France	6.1
Japan	8.9
Germany	9.9
United States	20.2

[5] AREVA Group financial results for 2002.
[6] DGEMP, 2002 provisional energy report for France.
[7] EU Energy & Transport in Figures – Statistical Pocketbook 2002 – European Commission.

OPTIMIZING SKILLS IN EUROPE

In the automotive and aeronautics industries, newer, safer, more economic and more user-friendly models are always on the drawing board. In the case of nuclear energy, the EPR – European Pressurized water Reactor – is technically ready to be built.

1 – TARGETED DESIGN OBJECTIVES

- The EPR was developed by Framatome and Siemens, whose nuclear activities were combined in January 2001 to form Framatome ANP, a subsidiary of AREVA and Siemens. EDF and the major German electricity companies played an active part 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, all of which have been met:

- **Meet the requirements of European utilities,** as laid down in a joint specification, the "European Utility Requirements". This specification was drawn up by electricity companies in Germany, Belgium, Great Britain, Spain, Finland, France and Sweden. The "European Utility Requirements" also make allowance for the specifications of operators in the United States, drawn up under the aegis of the Electricity Power Research Institute (EPRI).

- **Comply with the safety standards laid down by the French safety authority for future pressurized water reactors, in concert with its German counterpart.** In October 2000, the safety options adopted for the EPR were validated by the French Standing Group of Experts for Nuclear Reactors, with the assistance of German experts.

- Make nuclear energy even more competitive than energy generated using fossil fuels. **To this end, generate electricity that is 10% cheaper than that generated in an N4 reactor.**

The basic design work was completed in 1999. It was followed by technical and economic optimization studies. Almost 2 million hours of design and development were devoted to the project.

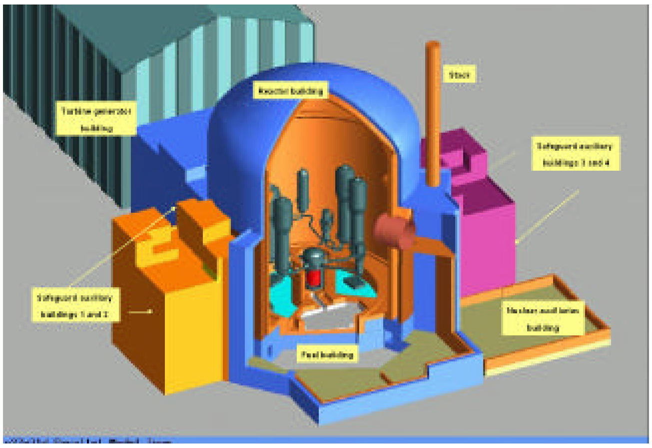
2 - MAIN CHARACTERISTICS

- 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 in Germany. **It benefits from over thirty years' operating**

feedback from nuclear power plants. Framatome ANP has built 96 nuclear reactors in 11 countries, representing almost 30% of the total installed nuclear power capacity worldwide.

- **The EPR is an evolutionary product not a revolutionary one** because it is based on proven technologies that include innovative features resulting from research programs carried out by the French Atomic Energy Commission (CEA) and its German counterparts. The EPR does not represent any technical break.

- **The EPR is a new generation reactor synonymous with significant economic and technical progress**: reduced electricity production costs, better use of fuel (UO_2 and MOX), reduced volumes of long-lived waste, improved availability, higher operating flexibility, fewer maintenance constraints and considerable reduction in the doses received by operating and maintenance personnel.



- **The EPR is based on pressurized water technology** – as are all the reactors currently in operation in France. **This is currently the most widely-used technology worldwide, with 209[8] reactors in operation**, out of a total of 440 representing various other types of technology.

- The EPR uses all the different types of fuel currently burned in pressurized water reactors: fuel containing slightly enriched uranium (up to 5%) and recycled fuel based either on reprocessed, re-enriched uranium or on mixed plutonium and uranium oxide fuel (MOX). **The core can be loaded entirely with MOX fuel. This means that the plutonium inventory can be controlled or even reduced and the volume of waste generated cut back.**

- The EPR has a net electrical power of around 1600 MWe. **This high unit output is particularly suitable for regions with extensive, robust electricity grids and areas in which the population density is high, with little space available for building power plants.** This is where half of the new electricity power generating plants to be built in the next 20 years will be located, regardless of the type of technology used.

[8] Elecnuc – Les centrales nucléaires dans le monde – Éditions 2002 - CEA

- **The EPR has been designed to have a service life of 60 years**, compared to 40 years for existing plants[9]. Thanks to the improvements made to equipment and components, **no major upgrading operations should be required during the first 40 years of operation.**

Main Characteristics		EPR	N4
Thermal power	**MW**	**4250/4500**	**4250**
Electrical power	**MW**	**Between 1500 and 1600**	**1450**
Efficiency	**%**	**36**	**34**
No. of primary loops		**4**	**4**
No. of fuel assemblies		**241**	**205**
Burn-up*	**GWd/t**	**> 60**	**45****
Secondary pressure	**bar**	**78**	**71**
Seismicity ***	**g**	**0.25**	**0.15**
Service life	**years**	**60**	**40**

* Average burn up of the fuel reloads
** Making allowance for maximum burn up of fuel assemblies currently authorized by the Safety Authority
*** Indicates the acceleration of seismic shoc ks for which safety systems are qualified

[9] This does not mean that the existing reactors will have to be shut down after forty years. On the other hand, no-one can predict which upgrades will be required at that time, or say how safety regulations will be possibly hardened by the Authority.

AN EVEN MORE COMPETITIVE REACTOR

With the EPR, it will be possible to generate electricity at an even lower cost of 10% less than that of electricity generated in N4 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 (1450 MWe).
- The construction time has been shortened, with only 57 months between first concrete and industrial commissioning.
- **Energy efficiency[10] has been increased to 36%**, a hitherto unmatched figure for light water reactors.
- The service life of the EPR has been extended to 60 years, instead of 40 years for the previous reactors.
- Better use is made of fuel. **With the EPR, 15% 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.
- Operating costs have been reduced:
  - **The number of actions carried out by operators has been reduced and made even more reliable,** due to the high quality of the man-machine interface and the ergonomics of the control room, simplified operation and the assistance provided to operators, and the high level of automation.
  - The general layout of the equipment is designed to **provide easier access and simplify maintenance operations, which are consequently carried out more rapidly.** Routine maintenance can be performed without shutting down the plant.
  - The length of the scheduled refueling outage has been shortened to 16 days. **Reactor availability can therefore be as high as 91% throughout its service life, compared to an average rate of 82% for the reactors currently in operation in France.**
- If the EPR were built, the cost of the electricity generated would be in the vicinity of 30 euro per MWh. **It would be 20%[11] less than the cost of electricity generated using gas, the main rival energy source.** What is more, the cost of electricity generated in nuclear plants includes external costs associated with R&D, spent fuel reprocessing, waste disposal and decommissioning, contrary to the cost of electricity generated using fossil fuels which does not include its external costs.

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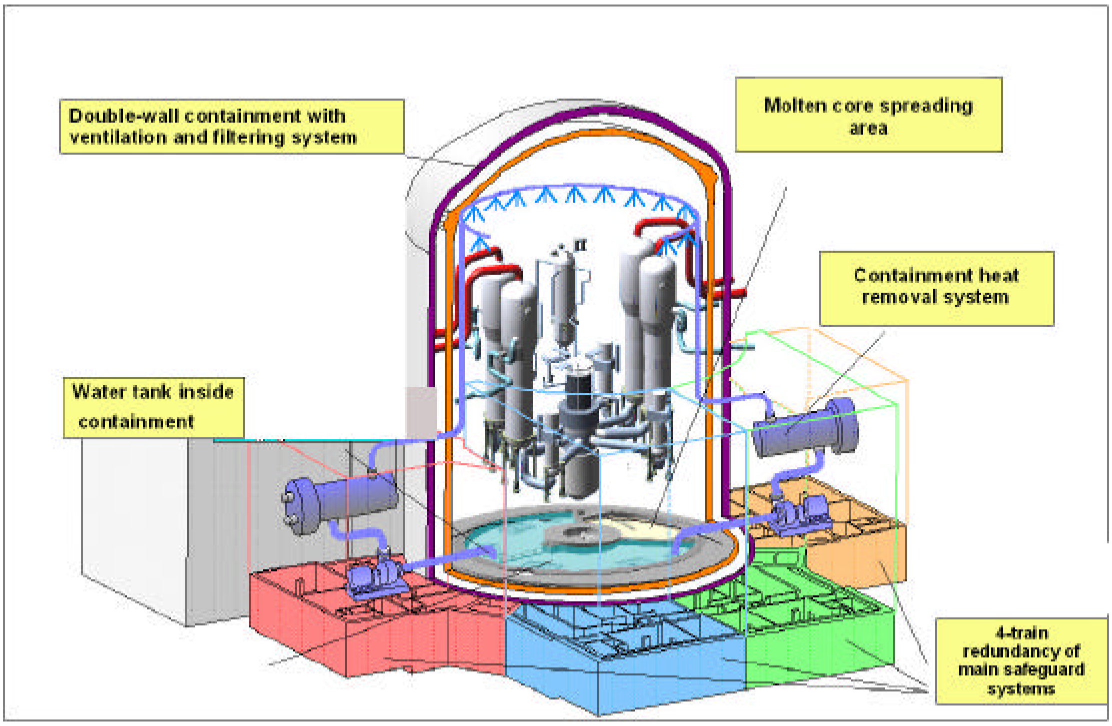
[10] Ratio between electrical power and installed thermal power.

[11] Cf. table on p. 4 - DGEMP and OECD studies, parliamentary report published by Messrs Galley and Bataille, study for the Prime Minister published by Messrs Charpin, Pellat and Dessus, Finnish study published by Messrs Rissanen and Tarjanne.

AN EVEN HIGHER LEVEL OF SAFETY

Safety in the nuclear industry is an integral part of continuous progress. Pressurized water reactors, such as the EPR, are extremely safe industrial facilities. **This high level of safety has been increased even further for the EPR.** After harmonizing their regulations, the French Safety Authority and its German counterpart laid down two requirements, both of which have been met.



1 – 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 system is subdivided into four identical sub-systems that perform the same function when an abnormal operating situation occurs, in particular to cool the core. Each sub-system is capable of performing the entire safety function on its own.** The sub-systems are totally independent and are housed in four separate buildings, each with its own individual protection system. They have been kept strictly separate. Thus, whenever the slightest fault occurs in one system due to internal (flooding, fire, etc.) or external (earthquake) incidents, another can take over and perform the concerned safety function.

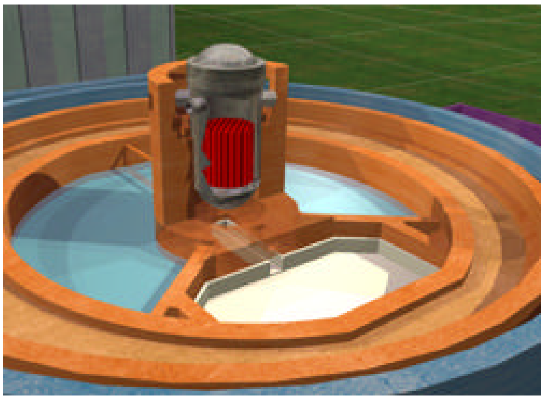
The likelihood of core damage occurring in current pressurized water reactors is already extremely remote but the EPR safety system architecture reduces it even further by a factor 10.

2 – AN EXTREMELY ROBUST, LEAKTIGHT CONTAINMENT

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

- **The EPR containment is the only one of its kind in the world.** The building housing the reactor is extremely robust. It rests on a 6 m thick concrete base mat and is enclosed by a double shell: the inner containment is made of leaktight, prestressed concrete and the outer one of reinforced concrete, each 1.30 m thick. This total 2.60 m concrete thickness is also capable of withstanding external hazards such as an aircraft crash.

Special tank



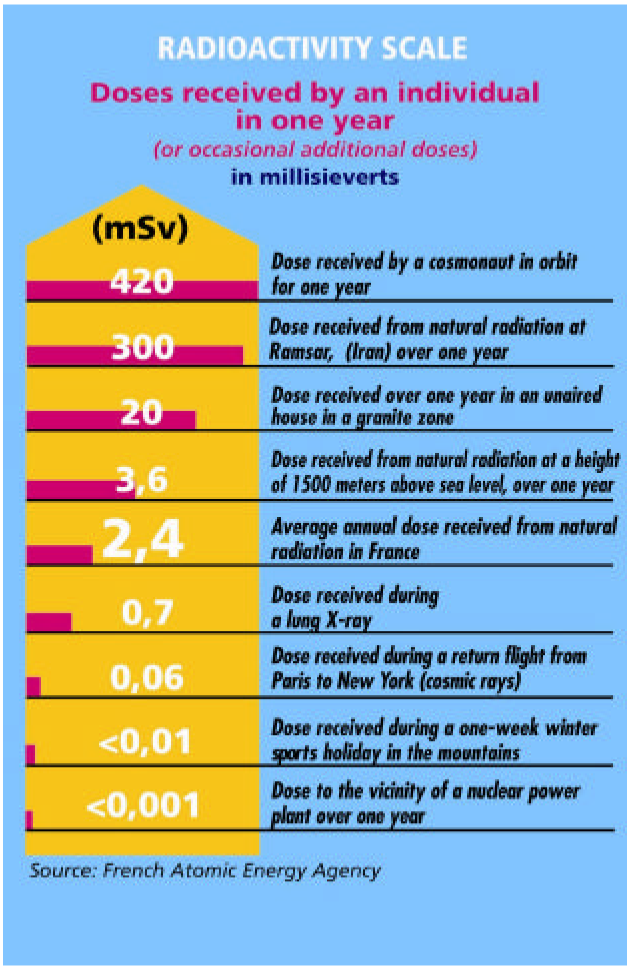
- Even in the highly unlikely event of the core melting, and piercing then escaping from the steel reactor vessel in which it is housed, it would be contained in a dedicated spreading compartment. This compartment is then cooled to remove the residual heat.

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

3 – REDUCING THE EXPOSURE OF OPERATING AND MAINTENANCE PERSONNEL

- With the EPR, radiological protection of operating and maintenance personnel has been intensified. The aim is to have a collective dose close to 0.4 man x Sievert per reactor per year, as opposed to the 1 man x Sievert which is the average annual value currently measured in nuclear power plants in the OECD countries, **meaning that exposure levels are reduced by more than half.**

- In French nuclear power plants, the annual collective dose of 1 man x Sievert for operation and maintenance personnel corresponds to average individual doses of around 5 milliSievert per year (mSv/year).
- By way of comparison, natural radioactivity levels in France vary between 1 and 6 mSv/year from one region to another, depending on the environment: 2.5 mSv/year in Paris and 5 mSv/year in Brittany and the mountainous Massif Central region.
- **In other words, the average occupational dose received in the plants is similar to doses received from natural radiation in France.**
- Furthermore, in some parts of the world, the doses due to natural radioactivity in the soil are considerably higher: more than 10 mSv/year in the south of India for example, rising to 175 mSv/year in some parts of Brazil and even 400 mSv/year in certain regions of Iran.



SOLUTIONS FOR EVEN GREATER PROTECTION OF THE ENVIRONMENT

The EPR has all the advantages of nuclear energy in that it does not emit any CO_2 or other greenhouse gases, nor does it pollute the atmosphere with sulfur and nitrogen oxides or ash, and in addition, it makes a considerable contribution to sustainable development.

- The EPR core has been designed to allow better use of nuclear fuel. To generate the same amount of energy, **the EPR uses less uranium, produces less plutonium generates less long-lived radioactive waste.**
- The EPR offers the possibility of reducing the plutonium inventory or keeping it to a predetermined level.
- Due to its extended lifetime of 60 years, for the same amount of energy generated, **it generates less ultimate waste to be managed after decommissioning of the plant.**
- Opting to use nuclear energy means preserving fossil fuel reserves which are set to reach peak production in the middle of this century, before beginning to dwindle again.

THE EPR IN FRANCE AND ABROAD

1 - FRANCE: BE READY TO TAKE OVER FROM EXISTING PLANTS

- **On October 21, 2004, EDF decided to launch a "head of series" EPR at Flamanville Normandy.** The project will begin in 2007 and should take five years to complete. The decision comes after the French government's announcement in June2004 that it intended to maintain nuclear's "considerable share" in the country's energy production, confirming the need for a third generation pressurized water reactor, the EPR, by 2015.

Context:

- The existing reactors in France were designed with an average service life of 40 years. They comply with very strict operating rules that are regularly monitored. **The reactors are inspected thoroughly every ten years, to determine whether or not their operating license can be extended for a further ten years.** This is not unlike the regular safety inspections our cars have to undergo.

- In 2020, 14 of the oldest reactors currently in operation will be at least 40 years old**. In 2025, they will be joined by 20 others, i.e. a total of 34 units accounting for 31,000 MWe or 50% of the power generated by existing reactors.** Since safety requirements will undoubtedly have been made more stringent by then, a greater amount of expense will be required to keep the oldest plants in operation.

- Likewise, in 2020, the annual demand for electricity (barring exports) will have increased by 33% assuming a realistic growth rate of 1.6%[12] per year. **As far as France is concerned, this will mean an increase in demand of 140 TWh. 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.

- Concerning the European market, there is expected to be an average annual growth rate in electricity consumption of 1.4% between 2000 and 2030, making allowance for energy savings; given that power plants of all types will be reaching the end of their service life, 600,000 MWe would have to be built to increase capacity by 330,000 MWe over this period[13].
- By launching construction of the EPR, the skills and industrial resources that have hoisted France to the pinnacle of the nuclear industry will be perpetuated; the operation of nuclear power plants in France and abroad will continue to be optimized, with the help of the electricity utilities.

[12] 1.6%: average annual growth rate in electricity consumption, between 1999 and 2020, as per the 1999 trend figures– Source: Les clés de l'énergie, édition 2001, DGEMP.
[13] Source: OECD International Energy Agency (World Energy Outlook 2002).

FINLAND

- On December 18 2003, the Olkiluoto 3 consortium set by AREVA and Siemens and the Finnish utility Teollisuuden Voima Oy (TVO) signed the contract for the construction of the EPR which is scheduled to start commercial operation in 2009. Upon the contract terms, the consortium will supply a turnkey point nuclear power plant.

- The Framatome ANP scope of work includes the supply of the nuclear island (NI) and the fuel first core, civil works, parts of balance of plant comprising access building, waste building and an EPR simulator. As leader of the consortium, Framatome ANP will coordinate the overall project including functional and technical integration of the complete plant.

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

Context:

- Energy has a fundamental role to play in Finland's economic development. The country has very few natural resources and imports more than 70% of its energy supplies. Electricity consumption is increasing steadily. According to the Finnish government, it will have risen by 25% by 2015. Electricity is generated from a variety of sources, with nuclear power plants accounting for 27%.

- With a view to becoming more self-sufficient while complying with the commitments made in the framework of the Kyoto protocol, the Finnish parliament has given the go-ahead for construction of a 5th nuclear reactor, considering as it does that nuclear energy is the best way of guaranteeing a steady supply of electricity with a low production cost, but no greenhouse gas emissions.

CHINA

- An official decision to build four duplicate reactors was announced on July 2004. In addition to these four duplicate reactors to be built on existing sites, China has decided to build four 3rd generation reactors at Yangjiang and Sanmen. An international call for tender was launched on September 28, 2004. AREVA will reply to the tender by offering its EPR model.

Context:

- The decision to opt for nuclear energy goes a long way to meeting the requirements of the Chinese market: an annual increase in industrial production of around 10% and a demand for electricity that greatly exceeds supply. In China, electricity supply will have to be increased by 20% to meet demand.

- China has considerable coal resources which explain that, at present, conventional power plants account for 75% of installed capacity. Unfortunately, these coal resources are located far from the energy demand areas, thus mobilizing more than half of the railway and waterways transport means. The Chinese authorities have therefore launched a policy to diversify their energy sources. Although nuclear energy has only a small part to play for now, it is bound to become increasingly important in the future. The 10th five-year plan (2001-2005) for the economic and social development of the nation states that "nuclear energy will be developed in an appropriate manner".

- On the strength of its know-how and experience acquired through the Daya Bay and Ling Ao contracts in 1986 and 1995 respectively, its involvement in the Qinshan project with the Nuclear Power Qinshan Joint Venture Company (NPQJVC) and the technology transfer program set up in 1991 with China Nuclear National Company (CNNC), Framatome ANP could propose the EPR to the Chinese authorities for any new plants to be built in the People's Republic of China.

3 - United States

- In view of the possible revival of the nuclear industry, as described in the government's "Nuclear Power 2010" program, the EPR is suited to the American market where regulatory site licensing procedures are particularly lengthy. Its high power would enable it to supply energy to thousand of consumers, without any need for the numerous procedures required for building less powerful reactors. It would also be an alternative to replacing coal-fired power stations.

Conclusion

Nuclear energy, which provides a steady supply of electricity at low cost, has its rightful place in the energy mix of the 21st century, which puts the emphasis on sustainable development.

The EPR is the only 3rd generation reactor under construction today. It is an evolutionary reactor that represents a new generation of pressurized water reactors with no break in the technology used for the most recent models.

The EPR can guarantee a safe, inexpensive electricity supply, without adding to the greenhouse effect. It meets the requirements of the safety authorities and lives up to the expectations of electricity utilities.