EPR, AREVA’S ADVANCED EVOLUTIONARY PWR ON TODAY’S MARKET

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The European base load generation fleet is now entering a reinvestment cycle after a period of overcapacity. The IEA reference scenario for Europe is an average yearly increase of almost 2% for electricity consumption, with over 250 GW in capacity nearing retirement and needing replacement.

This means that about 10 GW in new capacity must be connected to the grid every year between now and 2010 and 20 GW per year between 2010 and 2030.

In this context possibility of nuclear new builds in Europe in the near term has recently regained interest and many utilities are seriously considering this option in their future investment mix.

Three fundamental forces play in favor of nuclear in the mix for this new reinvestment cycle: economics, security of supply and environmental constraints.

The competitiveness of nuclear electricity has come under scrutiny in many countries over the past few years: France, Belgium, Finland and, more recently, the UK. In most of these European countries, the conclusion was drawn that nuclear is currently the best choice for base load production. This competitive position has been further reinforced by the recent upswing in fossil fuel prices.

Then there is energy independence. Over the past few years, security of energy supply has suddenly become a major strategic concern once again. In November 2000, the European Commission published a Green paper on the topic. The document highlighted the precarious situation of energy supply in Europe. In particular, the report predicted that, without any major policy change, European Union dependence on external energy sources would increase from 50% to 70% over the coming 30 years. Gas supply was also singled out as a major concern with North Sea production and wells nearing depletion and, as a result, increased imports from Russia and the Middle East.

The last factor is environmental constraints. All the scenario analyses show that increasing the nuclear contribution is the only realistic solution to stabilizing – and curbing – CO2 emissions. Without nuclear as a decisive contribution to the electricity generation, it will be simply impossible to meet Kyoto targets. The European CO2 emission market opened in January 2005 and has revealed a negative value of over 15 euro per metric ton of CO2. Obviously, this gives even further weight to the competitiveness of nuclear.

In response to this growing demand, AREVA is proposing its EPR reactor (Evolutionary Power Reactor). This reactor is the fruit of European cooperation dating back to the early 90s and involving four major utilities (E.ON, EnBW and RWE), the safety authorities of both France and Germany and the nuclear power plant vendors, Framatome and Siemens KWU whose nuclear activities have since merged.

EPR reactor advantages can be summarized as follows:

- Evolutionary design built on experience from the most recent reactors. Based on an advanced design, AREVA’s EPR is a 1600+ MW evolutionary reactor. Combining the best
Framatome (France) and Siemens (Germany) technologies, it benefits from the uninterrupted technological improvements acquired from all the previous AREVA-plants. It offers a very high level of safety and protection. Design advances and innovative elements provide an outstanding level of safety never before reached, with extended reaction time for operators as well as increased protection against internal and external hazards, notably airplane crash. The safety options of the EPR have been approved by a number of European safety authorities (including Finnish and French).

- Optimized generation cost achieved by the combination of several improvements: unit size, availability, simplified maintenance, fuel utilization, core management flexibility, steam cycle efficiency, extended plant life.

The EPR system architecture satisfies the following principles:

- Design based on simple principles. The most important safety functions are ensured by diversified systems. Combinations of functions that would increase the complexity of systems operation have been avoided.

- Physical separation. The different trains of the safeguard systems are installed in four physically separated divisions of the plant. Therefore, a common mode failure that might result from internal hazards (flood, fire, etc.) is eliminated.

- Functional diversity. The risk of common mode failures that could affect redundant systems has been reduced by systematically seeking functional diversity. If a redundant system is completely lost, there will always be a diversified system that can perform this function and bring the EPR unit to safe shutdown.

- Redundancy. Four-train redundancy is used for the main safeguard systems (safety injection, emergency steam generator feed water supply) and the associated support systems (electrical power supplies and cooling systems). The four-train architecture, along with a four-loop primary system design, contributes to the simplicity of operation. It provides flexibility to adapt the design to maintenance requirements during operation as well as during outages, when the redundancy level is increased due to lower residual power, and a lower load on the systems that may need to intervene.

Compliance with safety objectives related to severe accidents led to the incorporation of particular design measures:

- High-pressure core melt situations can endanger the integrity of the containment. In existing NPP units, the high reliability of the depressurization and residual heat removal systems make it possible to practically exclude this risk. In the EPR, a supplementary line of defense is provided: a set of motor-driven valves activated by the reactor operators palliates the potential failure of the other lines of defense.

- Exclusion of violent phenomena that can result from the production of hydrogen is provided by catalytic recombiners (about 40 of them) to consume the hydrogen. The pressure increases that would result from the combustion of hydrogen are taken into account in the containment design.

- Corium spreading and cooling can take place in a dedicated room next to the bottom of the reactor pit, whose walls and floor are covered with sacrificial concrete. A cooling structure under the spreading area allows for the extraction of the residual heat, the cooling and quick solidification of the corium. The erosion of the structural concrete of the base mat is thus prevented. An entirely passive device covers the layer of hot material and feeds this cooling structure with water from the In-Containment Refueling Water Storage Tank.
(IRWST), located next to the corium spreading chamber. In a second phase, after twelve hours, the Containment Heat Removal system is started which cools the spreading area. The design and general arrangement of the NPP buildings enables collecting possible leaks through the penetrations and filtering them before their release. This design meets the strict radioactive release objective imposed for next-generation reactors.

The EPR has been designed for maximum reactor efficiency with this technology and for the most efficient use of fissile material. The nuclear steam supply system (NSSS) design is compatible with a high discharge burn up. Intrinsically, high discharge burnup fuel reduces the volume of the high activity radwaste per unit of energy produced.

The secondary pressure (78 bars), which conditions the efficiency of the thermodynamic cycle in the secondary system, is the highest of its category. A net efficiency of more than 37% can be obtained by current steam turbines. This is the highest value for a Light Water Reactor.

Reducing scheduled outage duration to improve overall unit availability was, from the very beginning of this project, one of the key objectives. The general layout of the equipment has been designed to facilitate maintenance operations. System designs allow the performance of certain maintenance operations while the EPR unit is in operation thus reducing the amount of servicing done during outages. A standard refueling outage of less than 16 days is possible for performing all the necessary operations: reactor cool down, fuel unloading, inspection, maintenance, refueling, and then bringing the reactor back to normal operating temperature.

The short scheduled outages and a reduced number of unscheduled outages produce an overall availability of 92% over the EPR unit’s service life. The latest advances in instrumentation and control systems have been incorporated into the design, which enables highly developed surveillance functions to detect any anomaly and possibly trigger any limiting action that could prevent the untimely solicitation of a reactor trip system.

The EPR’s technical service life is 60 years, maximizing the plant's economic performance. All non-replaceable equipment, such as the reactor vessel or civil works structures, have been designed to reach this limit. All other equipment are designed to ensure a long service life, as well as ease of replacement should that be necessary.

Moreover, in terms of footprint, both literally (land use, environmental impact) and figuratively (administrative procedures, societal impact), a large reactor, such as the EPR, will be comparable to a significantly smaller one, making it an attractive choice when nuclear sites become more difficult to find, which is and will be increasingly the case for densely populated areas with the fastest growing energy needs.

A first EPR unit is under construction in Finland. The electrical utility TVO issued a call for bids at the end of September, 2002. Bids were submitted on March 31st, 2003. The contract was signed on December 18, 2003 between TVO and the consortium made up of Areva NP and Siemens Power Generation, respectively to be in charge of the Nuclear and Turbine Islands including civil works. It is the first new NPP construction in Europe since the completion of the N4 program with the commissioning of Civaux 2 in 2002.

Envisaged for several years, the decision to start the construction of a unit in France has been taken in 2004. Independent reviewers such as the French Parliamentary Office for Scientific and Technological Choices acknowledged in early 2003 that it was highly desirable to construct the head EPR unit to evaluate its operation prior to launching the EPR series to replace first generation NPPs.
A large public debate on the energy policy was organized in 2003. One of the issue discussed was whether or not it is necessary to build the head EPR unit in advance of the renewal of the EDF fleet. The Minister of Industry concluded publicly and clearly that the nuclear option must be kept open and that to reach this goal, an EPR unit should be built in France as soon as possible. This proposition was included in the law approved by the Parliament in June 2004. A few days after the vote the EDF board confirmed the commitment in view of the construction of an EPR unit. The next step was the selection of the Flamanville site in Autumn 2004.

The public hearing procedure has been launched and EDF has started the site preparation work. First concrete is forecast for 2007 and commissioning in 2012.

The construction of the EPR in Finland on the Olkiluoto site is a major milestone in the development of the EPR: the key options and economic merits have been proven in a highly competitive arena. A further milestone has been the decision to build the head EPR unit in France to prepare for the replacement of the EDF fleet.

With market drivers leading to resort increasingly to nuclear generated electricity, EPR holds all the cards for increasingly contributing to the European mix.