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EPR, Meeting the Challenges of the Nuclear Renaissance

Introduction

The nuclear renaissance is a hot topic in the specialized media. For those of us working in the nuclear industry, the advantages of nuclear energy are self-evident: in today's context of climate change awareness, this CO_2-free energy seems to be heading for a worldwide renaissance, and the question seems to be not the existence of this renaissance, but its extent.

However, compared with previous decades of high growth of nuclear power, the coming decades of nuclear new builds have a different flavour. Public acceptance is now more important than ever, and leads to unprecedented public debates and information campaigns. For outsiders who are not yet convinced, any mention of nuclear power raises thoughts of Chernobyl, or even Hiroshima. Nuclear power has its drawbacks, and the nuclear renaissance will need a heavy communications effort by everyone involved if it is to achieve its ends.

AREVA is one of the major players of the global nuclear industry. The group is studying nuclear renaissance scenarios, and is making every effort to serve the market with new reactor models, in particular the EPR. The evolutionary design of the EPR is based on the Generation 2 reactors currently in operation, enhanced with robust design choices and redundant safety systems that meet the demand for increased nuclear safety. The EPR is currently the highest capacity reactor available on the market, and it is this high capacity that offers utilities and governments competitive electricity and enables them to optimize the limited number of sites available worldwide.

In this paper, we will consider the different scenarios of the nuclear renaissance and describe how AREVA can play an active role in this renaissance.

The scenarios of the nuclear renaissance

Governments, European and international agencies and think-tanks have in recent years launched various studies on energy. Strategies and scenarios have been assessed up to 2020, 2030, or even 2050. All of these valuable publications have led to very different data and conclusions, but one point that they share is the larger role of nuclear energy than was common only a few years ago.

WORLD ENERGY OUTLOOK 2006

The *World Energy Outlook 2006*, published by the International Energy Agency at the requests of the G8 countries, considers energy prospects until 2030. Its standpoint is based on the economic consequences of strategic choices relating to energy policies. In this publication, a whole chapter is dedicated to nuclear energy. Three scenarios are listed:

- The very improbable baseline scenario is where global energy policies maintain the status quo. In this scenario, installed nuclear capacity in 2030 would be 416 GW (10% of all electricity generation).
- The alternative scenario takes into account current measures under discussion (GNEP, but also nuclear development in China and India). This scenario raises installed nuclear capacity in 2030 to 519 GW (14% of all electricity generation).
- A third scenario, called "beyond the alternative policy scenario", aims at maintaining CO_2 emissions at their 2004 level. With this scenario, installed nuclear capacity would reach 660 GW, i.e. an additional 140 GW of capacity. Among the seven measures proposed, only nuclear power is currently technically available. Other solutions include biofuels and hybrids, carbon capture and sequestration, etc.

For the first time, the *World Energy Outlook* includes a 40-page chapter on the prospects of nuclear, summarizing the advantages of nuclear power as "a **proven** technology for large scale baseload electricity generation that **can reduce dependency on imported gas and CO_2 emissions**". The economic competitiveness of nuclear power is compared with CCGT and coal. Increases in gas prices handicap CCGT electricity generation, and a comparison with coal still depends upon two main factors: CO_2 emission valuation and cost of capital.

In conclusion to this study, the prospects of nuclear seem much brighter than in former *World Energy Outlook studies*.

ENERGY TECHNOLOGY PERSPECTIVES, SCENARIOS & STRATEGIES TO 2050

The *Energy Technology Perspectives, Scenarios & Strategies to 2050* was published last year by the International Energy Agency in response to the G8 Gleneagles Summit that took place in July 2005 and to the International Energy Agency's Energy Ministers, who met two months earlier. Both groups called for the IEA to develop and advise on alternative scenarios and strategies aimed at a clean, innovative and competitive energy future. In this publication, the standpoint is based on strategic choices with respect to CO_2 emissions. The publication presents a snapshot of key energy technologies and assesses their potential to make a difference by 2050. It also outlines the barriers to implementing these technologies and the measures that can overcome such barriers. The main interest of this study is to extend the outlook over the 2030s, up to 2050. In this longer timeframe, trends are even more visible.

Various scenarios are studied:

• The Baseline scenario provides for no change to current energy policies. In this case, CO_2 emissions are almost two and a half times the current level by 2050, due in particular to an even greater reliance on coal, in particular in developing countries.

• The Five Accelerated Technology (ACT) scenarios demonstrate that "by employing technologies that already exist or are under development, the world could be brought onto a much more sustainable energy path". Using these technologies, CO_2 emissions in 2050 can be returned to today's levels, and oil demand can be moderated. The IEA has discussed and analyzed other aspects such as energy efficiency measures (which can reduce electricity demand by one third less than Baseline levels) that are out of our scope. The first solution to increasing CO_2 emissions (+20% over the last decade) is logically by employing carbon capture and sequestration (CCS). Nuclear is then the second of the "other important technologies" (with "renewables including biofuels, efficient use of natural gas, and hydrogen and fuel cells"). The difference between the five ACT scenarios is the assumptions about the pace of energy efficiency gains, the pace of cost reduction of major technologies (CCS, renewables, nuclear), and about how soon these technologies can be made widely available.

• A sixth scenario, TECH Plus, expands on these five ACT scenarios with optimistic assumptions "on the rate of progress for renewables and nuclear electricity generation technologies, as well as for advanced biofuels and hydrogen fuel cells in the transport sector".

The objective of this study is not to recommend one technology over others, but to propose policies to face up to the global energy issue. Focusing purely on technologies reveals that none can make a sufficient difference on their own, but that a pool of environment-friendly technologies should be developed instead. A real change will only happen if "government, industry and consumers [...] work hard together". Energy policies will play a major role. One proposed policy is, for example, economic incentives to advance the uptake of low-carbon technologies.
In conclusion, nuclear power is clearly one part of a more global solution.

AREVA's answer to serve the market

While nuclear capacity seems to be part of the solution, a nuclear renaissance does not mean that today's nuclear industry can build a new fleet of Generation 2 reactors. The requirements of the market have changed.

MARKET QUALITATIVE REQUIREMENTS

The first requirement coming from the public and from the safety bodies is clearly for a higher level of safety. Additional measures have to be taken to prevent the occurrence of events likely to damage the core. An extremely robust, leak-tight containment is compulsory, as well as reduced exposure of operating and maintenance personnel.

The second requirement, emanating from utilities, is for a more competitive reactor. Higher electrical power, increased efficiency, better use of fuel, extended service life, increased availability and simplified maintenance operations were all on nuclear utilities' wish-lists.

Last but not least, greater sustainability is now required of all industrial sites and power plants. Saving uranium resources, less plutonium emanation and less long-lived radioactive waste are also part of the deal.

AREVA has anticipated these requirements in the design of its Generation 3 reactors. AREVA is currently building its EPR reactor in Finland (Olkiluoto 3) and in France (Flamanville 3). Our paper will focus on this reactor design. EPR is one of the Generation 3 reactor designs proposed by AREVA. A BWR design is also currently available (the SWR 1000) and AREVA is currently involved with MHI in developing a 1000 MW Generation 3 PWR.

EPR CHARACTERISTICS

The following main characteristics of the EPR provide an adequate response to the market's needs:

• Evolutionary and safe,
• Powerful and competitive,
• Environmental integration, as compared with smaller reactors.

"Evolutionary" means that it offers the best compromise between tried-and-tested solutions and innovative features which, in particular, are needed to meet new safety requirements (e.g. Core-Melt or Airplane Crash scenarios).

This evolutionary design approach was made in full compliance with the stringent requirements of the French and German Nuclear Safety Authorities and of European utilities.

This philosophy was chosen not only to enable the EPR to be licensed more easily, but also to help utilities and governments in dealing with increasingly demanding public acceptance issues. The EPR goes with the choice of a solid design that reassures.

Generating in excess of 1650 MWe, the EPR is currently the most powerful reactor in the world. It is powerful and competitive, or rather, competitive because powerful. This is because size is a major factor in reducing specific costs, not only in terms of investment (€/kWi) but also in terms of production cost (€/kWh). This was the key criterion for the Finnish decision.

The EPR is also better integrated in its environment. Its small environmental footprint is to be understood both in the real sense (choice of site, environmental impact) and in the figurative sense (administrative procedure, societal impact). In fact, the administrative procedure and societal impact of such a high power reactor is comparable to one of a much lower output.

This means that AREVA's large size reactor will be part of the solution to the increasing siting difficulties in densely populated areas with fast growing electricity needs.

Conclusion

To become reality, the nuclear renaissance requires that all parties involved (vendors, utilities and nuclear safety authorities) effectively mobilize the necessary resources in their respective fields of responsibility, and are able to interact in an effective and responsible way.

References

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