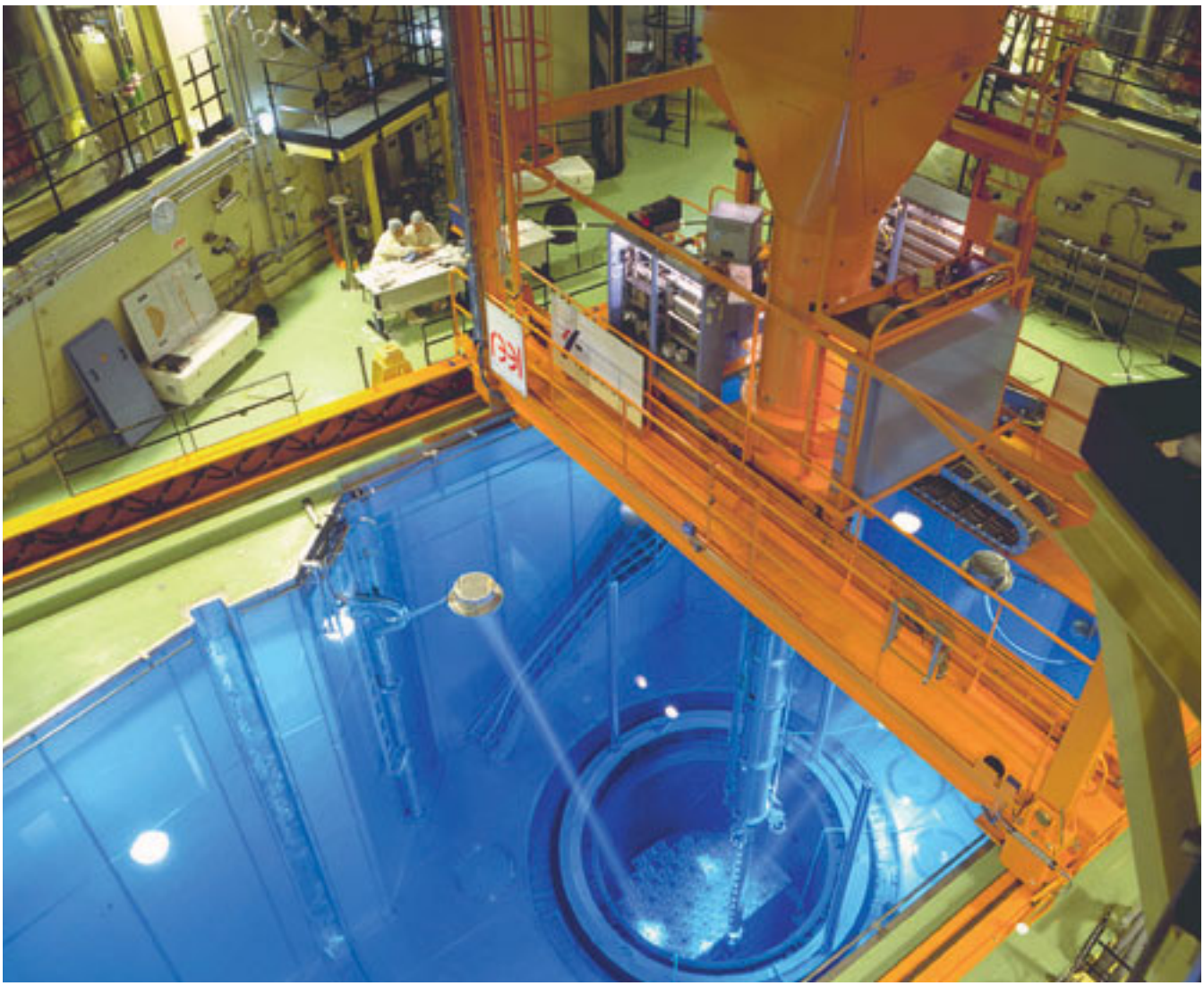
# NUCLEAR ENERGY – A SOLUTION FOR THE FUTURE

*Finding improved, sustainable ways of generating power, while reducing greenhouse-gas emissions is a major challenge for our planet. Nuclear energy presents unquestionable advantages in this respect. Indeed, development of nuclear solutions takes pride of place in the long-term energy policies of such countries as the United States, Japan or China. Thanks to a major research and development effort, in which France, and CEA, have been prime contributors, solutions are at hand for optimised radioactive-waste management, thus meeting the public's concerns.*



G. Liesse/Framatome ANP

***July 2002: loading fuel into the Ling Ao 2 reactor, designed by Framatome ANP (Areva Group). China is currently building eight reactors.***

The major challenges facing the energy community today are dictated by the requirements associated with the need for steady and sustained economic development. The global demand for energy is constantly on the rise and should double between now and the year 2050. Continuing to produce energy under current conditions poses three major problems: in the long term, the risk of exhausting current oil and gas resources within a few generations from now; in the medium term, uncertainties about fluctuating hydrocarbon prices that weigh so heavily on the economy, and the risk of losing sources of procurement; and in the immediate future, the need to combat global warming related to use of fossil fuels. Solutions must therefore be found to ensure improved and sustainable production methods, while reducing greenhouse-gas emissions.

In the context of these issues, which are crucial to the Earth's future, nuclear energy offers real advantages, including long-term resources (several thousand years if fuel use is optimized), and no greenhouse or toxic gas emission. Another positive factor is its competitive economic edge, demonstrated in France by the Charpin–Dessus–Pellat report submitted to the Prime Minister in 2000. This advantage should be driven home in coming years as the service life of reactors is extended and fuel performance is improved. The last point in favor of nuclear energy is that it guarantees energy independence.

It therefore comes as no surprise that major electricity-consuming countries have put developing nuclear energy high on their list of energy priorities. In the energy plan presented by President Bush in spring 2001, the United States government predicted that nuclear energy will remain key to America's energy policy and announced plans to increase the contribution of nuclear power plants to the nation's energy production (currently 20% with 100 reactors in operation). Furthermore, five nuclear reactors are being built in Japan, with seventeen more planned, while China currently has eight reactors under construction, with potentially many more to come, to mention but a few examples.

## On the way to fourth-generation reactors

Nuclear energy is a mature energy source. The reactors currently on the market are high-performance, mostly water-cooled systems. A major international program for cooperation in the nuclear field has been set up, mainly at the initiative of the United States, which launched the Generation IV International Forum in 2000. The Forum brings together ten countries, including Japan, the United Kingdom, France, and Canada, and focuses on research and development in future fourth-generation nuclear power plants to be put on the market by 2030. These future systems must meet a number of basic requirements. They must offer improved cost-effectiveness and safety, and make a fuller contribution to sustainable development, in particular by minimizing radioactive waste. They must also optimize the use of natural fuel resources and prevent proliferation.

In order to promote harmonious development and use of nuclear energy within this context, public concerns relating to the impact of nuclear activities on health and the environment must be addressed. The nuclear industry only generates small amounts of waste – in France, less than 1 kg per year per capita – and these can be managed safely. At present, 90% of this waste is low-level, short-lived waste and is disposed of in near-surface facilities operated by Andra – the French National Agency for Radioactive Waste Management – and monitored to ensure the protection of populations and the environment. In less than 300 years, its activity will have returned to the same level as natural radioactivity. The remaining 10% of waste has a longer half-life, sometimes twenty to thirty thousand years. It is currently placed in perfectly safe interim storage sites. Requirements in this field are stringent, and CEA research teams and their many partners are engaged in long-term programs to study and develop safe and effective technical solutions for use in radioactive waste management. The themes addressed are the reduction of the quantity and toxicity of waste, conditioning, storage and deep disposal. Such solutions already exist, but must be brought to scientific and technological maturity, including from the economic viewpoint, to offer a fully comprehensive range of management methods.

Research in this area follows guidelines laid down in the Act of December 30, 1991, which specifies three lines of research for long-lived radioactive waste management. Researchers have been given fifteen years to explore these three areas which are: 1) minimizing the quantity and toxicity of radioactive waste through partitioning and transmutation techniques, 2) conditioning and long-term storage, and 3) deep geological disposal.

## Waste: a highly positive assessment of the research effort

After ten years of research, during which CEA researchers and the other players and partners involved spared no effort, an extremely positive report can now be made. Significant results have been achieved, particularly in the two following areas:

- Minimizing the quantity and toxicity of waste: optimization of current spent-fuel reprocessing methods (waste volumes have been divided by three since the new La Hague plants were commissioned, while effluent and release activity has been divided by ten), a new chemical process has been developed for specifically extracting minor actinides (advanced separation), and the scientific feasibility of transmutation has been demonstrated.
- The groundwork for conditioning and long-term storage has now been completed: new conditioning matrices have been developed, better insight has been gained into long-term behavior of waste, and the initial concepts for casks and storage facilities assessed.

## Solutions are available

There is still room for progress and research has advanced further in some areas than others. Nevertheless, the most promising processes now stand out clearly. Radioactive waste management solutions exist that could be implemented gradually:

- The first stage would be reprocessing spent fuel and recycling plutonium to consume and eliminate it at the same time, as plutonium is both a high-energy source of fuel and the main factor in long-term radiotoxicity.
- Another stage could be to complement reprocessing operations with advanced separation of minor actinides, leading eventually to vitrified waste whose potential radiotoxicity would, after a few hundred years, drop to a level comparable with that of uranium when it is first mined.
- Minor actinides could then be transmuted in new-generation reactors that have waste transmutation and minimization included in their operating objectives, or in dedicated critical or subcritical facilities (hybrid systems).
- Deep geological disposal, which isolates radionuclides from the environment, could thus benefit greatly from this reduction in the quantity and toxicity of waste.
- Lastly, the 1991 Act also calls for investigations into long-term storage options to complete the range of solutions proposed.

In 2006, under the provisions of the 1991 Act, the French government and Parliament will decide on a set of complementary scientific and technical solutions leading to open-ended and flexible radioactive waste management strategies.

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