



Foreword



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To confront the challenges, crucial for the future of our planet, of meeting world energy requirements, nuclear power affords real advantages: resources extending into the long term (several thousand years, with optimization of fuel usage), with no greenhouse gas emissions.

On the international scene, an increasing number of countries are contemplating an expanded share for nuclear power, in their energy plans. This is the case, notably, of such countries, in Asia, as China, India, or Japan. In Europe, Finland has embarked on construction of a third-generation EPR reactor, and France is planning to do the same. The United States anticipate, in their energy plan, that nuclear power will remain a major component of their production policy for this sector. The United Kingdom may be about to follow suit.

Nuclear power is a mature energy technology, of proven economic competitiveness, and one which represents, for France in particular, a major factor securing the country's independence, in energy terms. Reactors currently on the market are high-performance models, mainly using light-water reactor technology. The waste generated amounts to small quantities, and is managed in safe fashion. As of now, in France, 90% of such waste, i.e. short-lived, low-level waste, is kept in disposal in ANDRA's surface sites, in such a way as to ensure populations, and the environment, are protected. The remaining 10% is long-lived waste, with half-lives ranging up to several tens of thousand years. This is held in interim storage, with full safety ensured. This waste is targeted by a research effort, conducted under the aegis of the French Act of 30 December 1991. These investigations, carried out in highly sustained fashion from 1992, have drawn on major collaborations in

France (EDF, ANDRA, CNRS, academia...), as on the European and world scenes. The appointed time for reassessment, in 2006, will enable the French Parliament to debate government proposals for the long-term management of this waste. To draw up these proposals, the government will be basing itself, in particular, on research work, the main scientific and technical results of which – obtained at CEA, in particular – are presented in this issue.

If nuclear power is to grow in harmonious fashion, the public's concerns must be addressed, with respect to the health and environmental impacts of the industry's activities. The range of fears raised by nuclear power, regarding the risks – real or imagined – involved for those working for the nuclear sector, or living close to industrial sites, has been swollen by denunciations of the hazards from the transport, and disposal, of radioactive waste, even though these activities have experienced no major accident. Such fears call for major efforts, in terms of information and scientific presentation, aimed at the populations concerned, and local and national elected representatives. Social acceptance of industrial options is an issue that strikes well beyond the sole nuclear power sector, and is of concern for our democratic system. CEA has played its part in this respect, as a protagonist in the sector, in particular through the opening of the Visiatome information area, at Marcoule, and sustained involvement in the public debates on radioactive waste management.

France has been a long-standing proponent of the closed cycle, whereby spent fuel is reprocessed to partition recoverable, reusable materials, and ultimate waste. This cycle presently allows the recovery, for recycling purposes, of energy-rich materials (uranium and plutonium), and the conditioning, in safe, durable fashion, of waste, in a small volume. That waste, nowadays, is held in industrial storage facilities. Looking beyond this, the chosen very-long-term waste management mode will have to ensure durable isolation from humans, and the environment, such that reemergence into the biosphere may only occur by a time when the health and environmental impact will have dwindled to insignificance.

Long-lived, high- and intermediate-level waste currently produced, or to be produced in the coming two decades, will be drawing the benefits, as a result of the research effort carried out, of the most advanced industrial technologies (volume minimization, very-high-performance confinement techniques). Industrial treatment and conditioning techniques have been optimized, resulting, in particular, in a massive reduction in the volume of solid waste produced at La Hague. These packages are durable: the development of a veritable science of long-term behavior has enabled the development, and qualification, of models allowing predictions of package behavior

in storage conditions, over timespans of centuries, or on a scale of millennia, in geological disposal conditions.

Industrial waste packages thus fabricated are intended to go into disposal as is, after a period in storage (in particular, in order to take advantage of a falloff in thermal power, in the case of vitrified waste). Existing, recent industrial storage facilities should have the ability to hold such waste for at least one hundred years. Storage facilities require maintenance, and monitoring by society, as well as the retrieval of packages at the end of their storage time. The durability of such a solution could only prove effective provided storage facilities are replaced and renovated at regular intervals, by future generations. This cannot be seen, therefore, as a very-long-term management mode.

The ability to store waste, in a fashion that is both safe and robust over extended timespans, is proven. Storage facility extensions, when they are required, will be able to take on board the results of investigations on long-term storage, with respect to robustness and passivity, in particular.

Nowadays, the first stage for the closed cycle, directed at separating recoverable materials from waste, consists in reprocessing spent UOX fuel, and recycling in PWR reactors the plutonium extracted, in the form of MOX fuel.

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Beyond this industrial monorecycling of plutonium, multirecycling it would allow a reduction in radiotoxicity by a factor 10 (at 500 years), compared to that of unprocessed spent fuel. The aim of ongoing investigations is to go further, in terms of a reduction of the radiotoxic inventory, this further inducing a falloff in waste thermics, in the long term.

On the basis of the findings obtained, it would not be realistic to recover long-lived radioactive elements from glasses already produced, or from other conditioned waste. Waste from the current fleet will go on being vitrified, and enhanced separation may only apply to waste to be produced at a future date, from the time new industrial reprocessing resources are deployed.

For such future waste, separation of long-lived elements has proved possible in the laboratory, this outcome representing a major breakthrough. Development work should proceed with a view to industrialization, in connection with the cycles of the future nuclear power generation systems.

As regards transmutation of minor actinides, the viability of dedicated, technically complex systems (ADSs) has yet to be demonstrated. In sodium-cooled, fast-neutron-spectrum reactors, the feasibility of americium and neptunium transmutation has been established, on the scale of a fuel pin. Materials suited to introduction into this type of reactor, for the purposes of carrying out such transmutation, will go on being tested in the Phénix reactor, and subsequently under the aegis of international demonstrations.

As regards the long term, the scenarios investigated show that separation–transmutation of minor actinides, along with plutonium and uranium, holds out prospects of deployment, in accordance with a staged-advances approach, in fourth-generation fast-neutron systems, which are planned to ensure the recycling, and management over time, of their own actinides. The decision to put a prototype on stream by 2020, and possible deployment around 2040 of the first industrial fourth-generation systems are to give shape to this goal for advances, making it possible for ultimate waste then to contain only fission products, for which investigations have shown that transmutation is not a reasonable industrial option.

A long-term management solution for such ultimate waste, as for the ultimate waste from current reactors, remains a requisite. ANDRA, on the basis of initial research work, carried out, in particular, in the Meuse–Haute-Marne (Eastern France) underground laboratory, has found that disposal in a clay environment is feasible in principle. Owing to the geological barrier, final geological disposal now appears, in the view of experts, as the reference solution, as being passive, and safe.

Thus, thanks to the combined efforts of research workers and manufacturers, major advances have been achieved over the past 15 years, in the management of radioactive waste, as it is currently carried out, and as it may be envisaged for the future. This approach of sustained advances will go on supporting the next stages in the development and growth of nuclear power, with regard to existing waste, as for future waste.

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