Nuclear energy for the future:

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The time constants involved in nuclear energy are long: several decades are required, to develop a new "generation" of nuclear systems (reactors, and cycle), and reactors built today will still be operating in the latter half of this century. Nuclear energy R&D thus calls for continuity in terms of energy policy. If France, nowadays, stands as a world leader in this area, it is because the country has been able to secure a degree of political consensus, as to the advantages of nuclear energy.

At the same time, the global energy context is fast changing: in the years around 2000, hydrocarbon prices were depressed, and there were questions, in Western nations, as to the future of nuclear energy, deemed to be more complex than natural gas for the purposes of electrical power generation. Presently, rising energy needs, particularly with respect to electrical power, heavy strains on hydrocarbon prices, geopolitical uncertainties as to petroleum and natural gas supplies, and the emergence of the climate hazard as the major environmental challenge at the outset of this century are inducing a resurgence of nuclear energy the world over, in the United States in particular, and a speeding up of programs across Asia, in India, or in Russia. Europe, home as it is to unrivalled expertise, and operational feedback, is evincing a renewed interest for this source of energy, seen to be indispensable in the context of a strategy to promote energy security, and the curbing of CO_2 emissions. Bolstered as it is by a consistently reaffirmed commitment in this respect, France can rely on the best assets to participate in this renaissance of nuclear energy at the industrial level, with third-generation reactors such as EPR, a high-performance fuel cycle, but equally through the advances that are anticipated with Generation IV systems, which should allow true sustainability to be achieved for fission nuclear energy, through better utilization of resources, and a reduction in the volume, and radiotoxicity of ultimate waste.

The renaissance of nuclear energy, and its sustainability, beyond the present century, raise the issue of uranium resources. This issue of *Clefs CEA* reviews the available evidence on this matter, and the R&D strategy this entails.

Industrial competition, cooperation in R&D

While the third generation of reactors, already reaching industrial deployment, is subject to stiff international competition, in which the Areva Group is well positioned, with EPR, the ground for the fourth generation is being laid under the aegis of internal cooperations, through the Generation IV International forum, launched in 2000, bringing together twelve major nuclear energy nations, along with the European Union, through Euratom. Beyond the international framework, many bilateral collaborations have been set up between France and most of these countries – the United States, Japan, China, Russia… – regarding fourth-generation systems.

The Generation IV Forum context is intended to allow a pooling of R&D efforts, thus helping to keep the range of possibilities open. France has committed itself to R&D programs on technology lines for which it can already draw on extensive expertise – sodium-cooled fast reactors – or which are seen as being particularly promising: the gas-cooled fast reactor line, requiring more by way of technological innovations, particularly with respect to materials, and fuels. Research work is also being carried out in partnership with manufacturers, for very-high-temperature reactors, which could have applications outside of electricity generation – production of process heat for industry, seawater desalination.

towards a sustainable renaissance

Such investigations are reviewed in detail in this issue of *Clefs CEA*.

Concurrently with research on reactors, investigations are being carried out on the fuel cycle – spent fuel reprocessing, and recycling. The French closed cycle strategy is now seen – even in the United States, with the GNEP initiative – as the only sustainable option, i.e. the only one allowing at the same time savings in uranium resources to be achieved, and reductions in ultimate waste, ensuring responsible waste management is feasible. The process developed by CEA, used on an industrial scale by Areva, and transferred to the Rokkasho-Mura plant, in Japan, is currently the only such process benefiting from operational feedback. Innovative evolutions, for third-generation, and further on for fourth-generation systems, are being investigated. These will aim to ensure even higher-performance waste management, and preclude proliferation risks, by featuring options for the processing of minor actinides. These investigations are likewise presented in this issue.

"A long-term commitment, the precondition for nuclear energy innovation."

The issue further features an overview of the tools required for R&D for the nuclear systems of the future: multiscale, multiphysics simulation tools, on the one hand, and experimental instruments, on the other hand, including the coming Jules Horowitz Reactor (JHR), construction of which has begun at the Cadarache site, bringing together, aside from EDF and Areva, many partners in industry, and from R&D organizations in other countries. This experimental reactor is intended to take over from existing installations, OSIRIS in particular, and will allow work both on reactors in the current fleet (second and third generations), and on fourth-generation reactors.

CEA's steering role in the European Research Area

The experimental facilities required for nuclear energy R&D, whether for current systems, or systems of the future, are nowadays designed on the scale of the European Union, allowing specialization and complementarity to emerge, across member states. Many projects are conducted in partnership with European laboratories, and the European Joint Research Center, under the aegis of the 6th Framework Program, in particular with respect to safety, and reducing ultimate waste toxicity, and volume. The setting up of a technology platform on fission nuclear energy, bringing together research organizations, manufacturers, and other stakeholders, on the lines of existing platforms for other energy technologies, will allow a further strengthening, and optimization, of such partnerships.

Currently, nuclear energy accounts for some 30% of European electrical power production, and is contributing to curbing CO^2 emissions, while guaranteeing low, stable production costs. It is vital, if Europe is to retain its economic attractiveness, with respect to electricity-intensive industries, that such assets be preserved. For that purpose, it is imperative, as of now, to bolster further still nuclear energy R&D programs, at the European level, in order to benefit from the best possible synergies, in terms of expertise, and experimental instruments.

This issue of *Clefs CEA* aims to provide a general overview of the advances, innovations, and technological breakthroughs that are required, to ensure construction of a sustainable, safe nuclear energy, allowing savings in natural resources, and enhanced proliferation resistance.

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