

Trends in Nuclear Power

Nuclear energy development

At the end of 2002, 362 nuclear power units were connected to the grid in OECD countries, providing approximately 24% of total electricity supply in the OECD area. Three new nuclear power units were brought into operation: one in the Czech Republic and two in Korea; two units were retired in the United Kingdom. Seven units were under construction: three in Japan, two in Korea and two in the Slovak Republic. While total electricity generation in OECD countries is projected to increase in the next decade, the nuclear share is likely to decline slowly due to expected closure of ageing plants. Licence extensions and the commissioning of new units will, however, offset part of this trend.

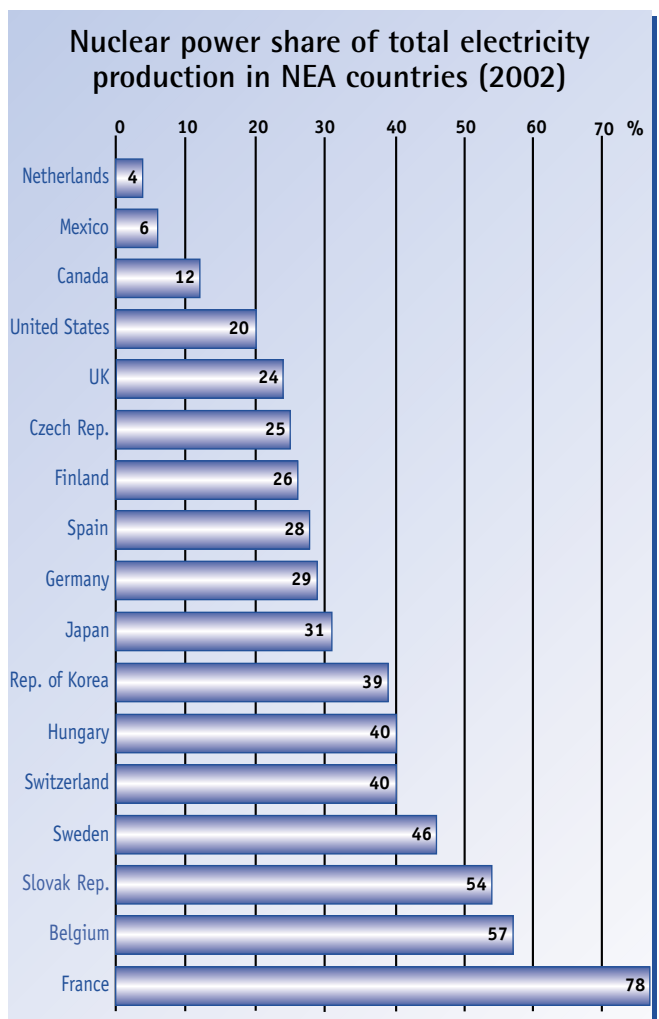
Some OECD member countries have recently been showing renewed interest in nuclear energy due to its potential role in ensuring stable energy supply, increasing diversification and reducing external dependence on oil and gas, as well as alleviating the risk of climate change. The nuclear option has been brought back on the agenda of several energy policy makers in Europe and North America. For example, the "G8 energy summit", held in Detroit, Michigan (United States), stressed the importance of the nuclear option for energy security and diversification, and environmental protection.

The role of nuclear energy in reducing carbon dioxide emissions and alleviating the risk of global climate change has been recognised by several national and international studies and fora. For example, the Performance and Innovation Unit (PIU) report in the United Kingdom recognised the role of nuclear power as a carbon-free energy source and the EU Green Paper on energy noted the contribution of nuclear energy to meeting the Kyoto Protocol targets. However, the role of nuclear energy in sustainable development remained a controversial issue at the international level as demonstrated by the World Summit on Sustainable Development (WSSD), held in Johannesburg, South Africa, and the 8th Conference of the Parties to the UN Framework Convention on Climate Change (COP8), held in New Delhi, India.

In the United States, the Secretary of Energy released a "Roadmap to Deploy New Nuclear Power Plants in the United States by 2010", which concludes that "New nuclear plants can be deployed in the US in this decade, provided that there is sufficient and timely private-sector financial investment." At present, the industry is reviewing several reactor designs. In Finland, the Parliament authorised industry to pursue the project of constructing a new nuclear power plant. This was based on the conclusion that, in addition to the favourable consequences on reduced CO₂ emissions, the nuclear option chosen would have a more positive impact on both unemployment and the national economy.

On the other hand, some European countries are pursuing nuclear phase-out policies with varying speeds and horizons. For example, in Belgium and Germany nuclear phase-out laws have been introduced and implementation measures are planned for the coming years. However, in all countries that have chosen to relinquish the use of nuclear power, the implementation of alternatives remains an issue in the face of increasing electricity demand. In this context, Sweden, which decided on a phase-out in 1981, postponed the early closure of nuclear power plants due to the lack of appropriate alternative energy resources. To date only one unit has been shut down.

Electricity market deregulation has progressed in many member countries, accelerating consolidations of power plant ownership and mergers in the industry at the international level. The European



Union (EU) is in the process of completing an agreement on full deregulation of domestic electricity markets within several years. At the same time, market liberalisation has pushed many utilities to enhance economic effectiveness through increased availability factors, lifetime extensions and capacity uprating. Such highly competitive situations have led to the downfall of some. An example is the financial failure of the nuclear electricity generator British Energy plc in the UK, which arose following the introduction of new electricity trading arrangements there. Difficulties are also, however, being experienced by fossil-fuel electricity generators. Generally speaking, existing nuclear power plants are competing successfully with gas- and coal-fired power plants owing to their low marginal production costs and their good safety and reliability performance. Lifetime extensions and capacity uprating have proven to be cost-effective in many cases and often the cheapest way to increase electricity generation, provided that nuclear safety and regulatory requirements continue to be met.

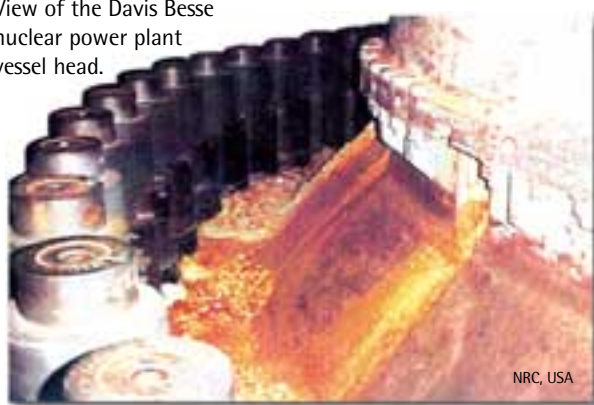
In a long-term perspective, the renewed interest in nuclear energy is demonstrated by international endeavours seeking to develop and deploy a fourth generation of nuclear energy systems that will respond to society's future needs. In particular, the Generation IV International Forum (GIF), a group of ten countries, released in December 2002 a comprehensive report entitled "A Technology Roadmap for Generation IV Nuclear Energy Systems".

The GIF Roadmap proposes international R&D programmes to demonstrate the viability and performance of six systems identified by the project members as promising in terms of: sustainability; safety and reliability; economics; and proliferation resistance and physical protection. The anticipated schedule, based upon the assumption of increased international collaboration in the field, would bring Generation IV nuclear energy systems to the market by the 2030 timeframe.

Nuclear safety and regulation

The safety performance of nuclear power plants in OECD countries continued to be very good, as reflected in a wide range of published performance indicators. Nevertheless, a number of significant events took place in 2002. Some of the most important were the corrosion of the reactor pressure vessel at the Davis Besse-1 plant (United States) and pipe ruptures due to hydrogen deflagration in the Hamaoka (Japan) and Brunsbuettel (Germany) nuclear power stations.

View of the Davis Besse nuclear power plant vessel head.



The analysis of operating events indicated that aspects requiring close attention include organisational change, hardware modifications, loss of technical expertise and loss of corporate knowledge. Issues of special relevance that were discussed by the OECD regulatory bodies in 2002 included the decommissioning of nuclear reactors, public communication, performance indicators both of nuclear safety and of regulatory effectiveness, maintaining nuclear safety competence, external hazards and regulatory requirements for future nuclear reactors. The cover-up by some utilities in Japan of the recordings of licensee self-imposed inspection activities demonstrated the need for greater safety awareness as well as strict control by national safety authorities.

Radiation protection

In 2002 radiation protection philosophy and application continued to evolve. Much of this evolution is driven by modern approaches to risk governance aiming at stakeholders' needs being more directly taken into account in accepted solutions. Several areas of broadest concern are reflected in ongoing international discussions. First, there is a desire to simplify and clarify the internationally accepted system of radiological protection, based on the 1990 recommendations of the International Commission on Radiological Protection (ICRP), as the system has grown to be very complex and contains certain discrepancies. Here, more focus is being put on case-specific national and cultural differences. It has also been recognised that technical aspects are only part of the necessary input for decisions regarding radiological protection; societal aspects must also be considered.



The health physics laboratory at Callaway nuclear power plant, in the United States, where environmental samples are measured for radioactivity.

Another concern is the radiological protection of non-human species, which is being addressed in a sustainable development context. The philosophy of what needs to be protected and why, and its scientific underpinning, are being further developed. Finally, work is under way to develop clear guidance on radiological protection from naturally occurring radioactive materials.

The radiation protection community continued its reflections on nuclear emergency management, focusing on possible longer-term aspects of decisions in this area. Interest and activity also increased in response to radiological accidents, such as lost sources, and as related to possible terrorist acts.

The radiological exposure of workers in nuclear power plants seems to have reached a level that can be called "as low as reasonably achievable" (ALARA). Over the past decade, exposures have fallen significantly and consistently, but are now beginning to show a more stable trend. This most likely reflects the balance that has been achieved between the need to perform dose-causing maintenance work on an ageing fleet of plants for nuclear-safety and/or plant upgrading, and the need to maintain worker exposures ALARA.

Radioactive waste management

The US spent fuel programme took a major step forward in July 2002 when the US Congress voted to endorse the Department of Energy's selection of Yucca Mountain as the site for the first national long-term geological repository for radioactive waste. Approximately one month later the President confirmed the Congress's action, paving the way for the next stage of the process; the Department of Energy will prepare and submit a construction licence application to the Nuclear Regulatory Commission. When considered with the developments in Finland and Sweden on repository siting, a clear trend can be seen towards implementing, in a realistic and practical way, measures for the final disposal of spent fuel and high-level waste (HLW).

In Canada and Germany, where significant ongoing waste management projects had been delayed, important steps have been taken to restructure the national programmes. In Germany, a committee, established by the government following the moratorium on the Gorleben site exploration, proposed a new procedure and general criteria for site selection which include both societal and geoscientific aspects. Regarding the disposal of waste with negligible heat generation, a licence has been given to convert the Konrad mine into a repository for radioactive waste. By the licensee's choice, however, the licence will not be executed until all court cases are settled. In Canada, a new Nuclear Fuel Waste Act entered into force in November 2002, which puts the onus on the waste owners to recommend an approach to managing the waste and to finance the long-term management. It also requires the establishment of a non-profit waste management organisation, which must consult with the general public.

Mixed messages came from Switzerland. The national implementer, NAGRA, submitted a feasibility study for disposal in Opalinus Clay, which demonstrates that high-level waste and spent fuel can be safely disposed of in Switzerland, and which will facilitate decision making in 2006 on further procedures for managing these wastes. New obstacles arose, however, for the long-term management of low- and intermediate-level waste when the Nidwalden canton rejected for the second time by public vote a project on research for, and construction of, a final repository for these wastes in the Wellenberg area. This negative vote may have reverberations on the forthcoming discussions on the nuclear law.

Finally, progress was noted in Japan, where the national implementing agency NUMO officially announced the start of "open solicitation for volunteers for primary investigation areas" for a HLW repository. This approach is based on the need for local community support in conducting a geological disposal programme for HLW, and is part of a three-tiered approach outlined in the radioactive waste disposal act of 2000.

Nuclear science

New challenges in the field of nuclear science are mainly related to proposals emerging from the recently launched studies on advanced reactor technology, for example those of the Generation IV International Forum (GIF), and continued studies on the feasibility of partitioning and transmutation of nuclear waste.

During the GIF selection process of new reactor concepts to be studied, considerable interest was expressed in high-temperature, fast reactors with closed fuel cycles. To respond to these interests, new materials that can withstand the high temperatures and also have good irradiation characteristics will have to be developed. In addition, the proposed closed fuel cycle option will initiate more research in the field of fuel reprocessing chemistry, for example pyrochemistry (dry reprocessing) methods.

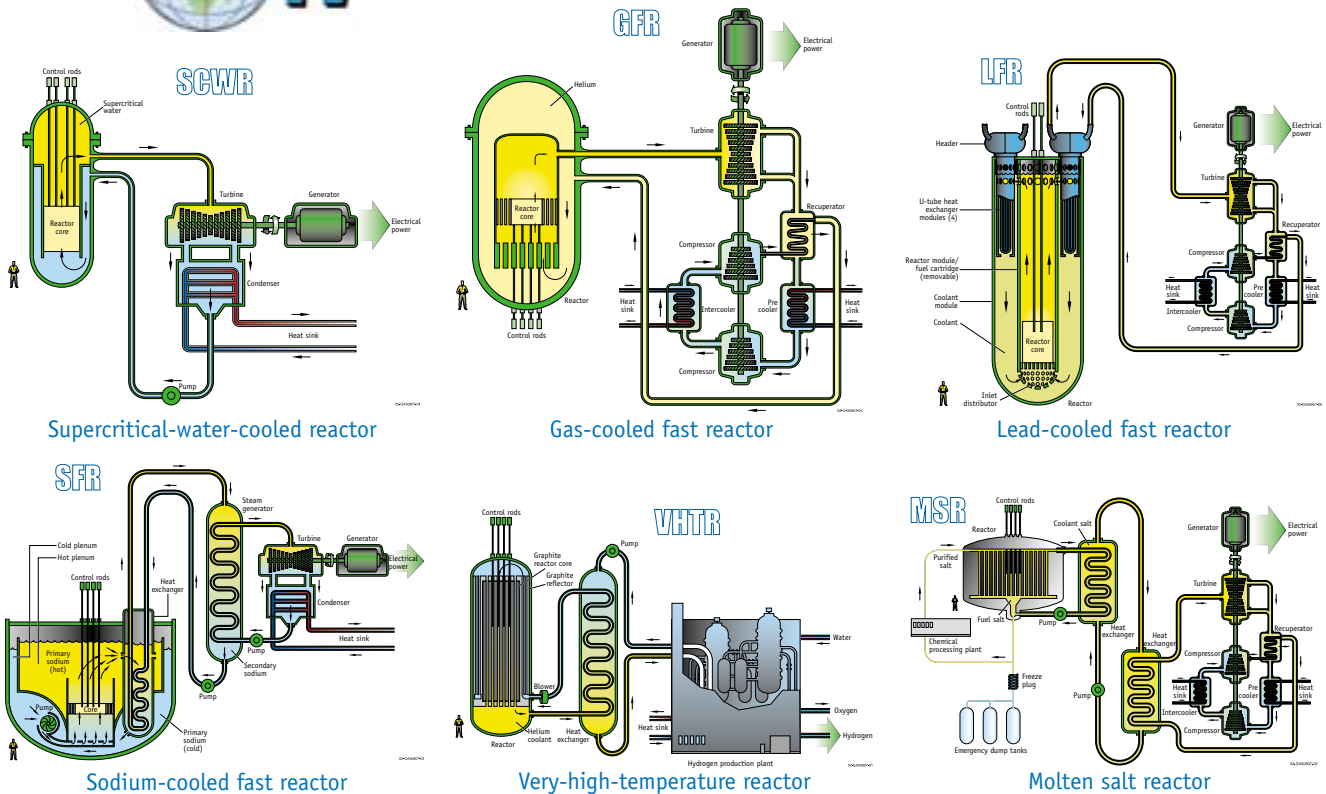
Studies are being pursued of different options to transmute nuclear waste, and therefore reduce the duration of its radiotoxicity and the volumes requiring disposal. The options for transmutation

Entrance to one of the tunnels at the Yucca Mountain site for radioactive waste disposal.





The next generation of nuclear reactors



include both conventional reactors and more advanced accelerator-driven, sub-critical reactors that use different coolants. Programmes are being carried out to model these systems in order to validate, against experimental data, both the calculation methods and the data used, before constructing any demonstration system.

Knowledge preservation and nuclear data

To validate both present and future nuclear systems, there is a need for well-documented experimental data and computer programs. In order to meet this requirement, it is important to collect and classify, in a central place, the information already available in laboratories around the world. This is especially important in today's context when the skilled workforce in the nuclear field is declining and experimental installations are becoming scarce. This issue of knowledge preservation is presently being addressed by the major international organisations working in the nuclear field.

Nuclear law

Modernising the international nuclear liability conventions and encouraging adherence to them will help ensure the equitable compensation of nuclear damage in the event of a nuclear incident, while at the same time facilitating international trade of nuclear materials and equipment. In response to efforts made by the international

community in 1997 to reform the Vienna Convention on Civil Liability for Nuclear Damage and to establish a global Convention on Supplementary Compensation for Nuclear Damage, the Contracting Parties to the Paris and Brussels Supplementary Conventions completed their negotiations on the revision of both Conventions, approved the final texts of both amending Protocols and agreed to convene a diplomatic conference in 2003 to adopt the Protocols. The major reasons for this revision were to ensure that significantly higher compensation amounts would be made available to a greater number of victims for a broader range of nuclear damage suffered, while at the same time ensuring compatibility with other international instruments in the nuclear liability field.

The trend towards strengthening institutional and legislative frameworks in the nuclear energy field in the countries of Central and Eastern Europe and the New Independent States remained evident. Countries from these regions continued in their efforts to adhere to the international nuclear conventions and to adopt or modify their national legislation accordingly.

The marked interest in maintaining a specialised summer course on nuclear law at the University of Montpellier 1, in close co-operation with the NEA, has been firmly demonstrated by the success of the first two sessions and in the number of applications received. This programme meets the concerns of OECD member countries to ensure that nuclear education and training are maintained at a high level, including in the field of nuclear law.