Nuclear Power in 2006

Nuclear energy development

At the end of 2006, 346 reactors were connected to the grid in OECD countries constituting some 83.6% of the world's total nuclear electricity generating capacity and about 23.1% of the total electricity supply in the OECD area. During 2006, one reactor was started up in Japan and six reactors were shut down in other OECD countries (four in the United Kingdom and one in the Slovak Republic, all on 31 December 2006, and one in Spain earlier in the year).

Although OECD countries continue to have different approaches to the production and use of nuclear energy, including in some cases official moratoria or phase-out policies (Austria, Belgium, Germany, Italy, Spain and Sweden), growing concern about energy security, rising prices of fossil fuels and carbon-dioxide emissions have stimulated new debates on the role of nuclear power throughout the OECD area and around the world. Major events that exemplify this renewed global interest in 2006 include the G8 endorsement of nuclear energy following the St. Petersburg meeting; a majority of European Union (EU) leaders giving strong backing to a revival of nuclear power at an EU summit; the government of Australia recommending to give consideration to building new nuclear power plants and that of the United Kingdom to replacing ageing plants; an energy policy review commissioned by the government of Belgium recommending reconsideration of the country's nuclear phase-out policy; and the government of the Netherlands establishing the conditions under which it would be possible to build new nuclear power plants. Plans to increase nuclear capacity were also announced in 2006 in several OECD countries:

- In Canada, the government of Ontario confirmed that nuclear power will be an important part of its plan to address looming energy shortages. Two new reactors are expected to be built and feasibility studies on refurbishing the Darlington and Pickering nuclear power plants are to be initiated. Both Ontario Power Generation and Bruce Power applied for Canadian Nuclear Safety Commission licences to prepare sites for the construction of new reactors.
- In France, the Board of *Électricité de France*, the primarily state-owned electricity utility, approved construction of a 1 630 MWe European pressurised water reactor (EPR) near Flamanville in the Basse-Normandie region.
- In Japan, a second unit at the Shika nuclear power plant (a 1 300 MWe advanced boiling water reactor) started commercial operation, while construction of a third unit at the Tomari nuclear power plant continued. Current plans include the construction of additional units.
- In the Republic of Korea, construction of the Shin Kori nuclear power reactors began in June and preparation of the Shin Wolsong site continues. Korea Hydro and Nuclear Power placed a USD 1.2 billion order with Doosan Heavy Industries for the first pair of third-generation APR-1400 PWRs (Shin Kori units 3 and 4).

2006 Nuclear Data Summary (as of the end of 31 December 2006)

	Operational reactors	Installed capacity (GWe net)	2006 uranium requirements (tonnes U)	Nuclear share of 2006 electricity production (%)
Belgium	7	5.8	880	54.4
Canada*	20	12.5	1 600	15.6
Czech Republic	6	3.5	664	31.5
Finland	4	2.7	467	28.4
France	59	63.3	7 184	78.1
Germany	17	20.3	3 400	27.0
Hungary	4	1.8	379	38.3
Japan	55	47.1	8 352	34.2
Mexico	2	1.4	200	4.7
Netherlands**	1	0.5	65	3.7
Republic of Korea	20	16.8	3 600	39.0
Slovak Republic	5	2.0	491	57.6
Spain	8	7.3	1 726	19.8
Sweden**	10	8.9	1 600	44.9
Switzerland**	5	3.2	270	37.9
United Kingdom	19	10.9	2 165	18.9
United States	104	99.9	22 890	19.4
Total (OECD)	346	307.9	55 933	23.1

* Estimates. ** 2005 data.

- In the United States, the Nuclear Regulatory Commission (NRC) proceeded to review four applications for early site permits for new reactor construction, and renewed operating licences for five nuclear power plants for 20 years, bringing the total number of US licence renewals to 47. The NRC also approved six power uprate applications in 2006, amounting to a total of 1 057 MWe of electricity generating capacity.

In non-OECD countries, three new units came on line in 2006 and construction of another three began. Plans for robust expansion of nuclear electricity generating capacity in China, India and the Russian Federation were initiated, and consideration is being given to either increasing existing capacity or to introducing nuclear energy in a number of other countries (e.g., Argentina, Bulgaria, Egypt, Indonesia, Romania, South Africa and Vietnam).

On a global level, plans for the development of international nuclear fuel cycle programmes were announced in 2006 by the governments of the United States (the Global Nuclear Energy Partnership) and the Russian Federation (the Global Nuclear Infrastructure Initiative). Although both programmes are in the early stages of development and differ somewhat in detail, they are both directed at elements of security of supply and include possible used nuclear fuel take-back and reprocessing components. The governments of France, Japan and the Russian Federation also placed priority in 2006 on the development of fast reactors. Successful deployment of fast reactors in the coming years could lead to significant changes in global nuclear development and nuclear fuel cycle activities.

Uranium production, conversion and enrichment

Preliminary data indicate that in 2005 uranium was produced in just five OECD countries, one of which produced only small amounts as part of mine remediation. However, Canada (28%) and Australia (23%) accounted for slightly more than half of world production. Production in OECD countries amounted to approximately 22 000 tonnes of uranium (tU) in 2005 and is expected to decrease slightly in 2006. This production accounted for only about 40% of the uranium requirements in the OECD area, with the remainder being met by secondary sources (for example, excess commercial inventories). For a complete picture of the uranium market see *Uranium 2005: Resources, Production and Demand*.

Since late 2001, the price of uranium has been rising, with the spot price nearly doubling in 2006 alone. This increase in price, coming after nearly two decades of sustained low prices, has stimulated a considerable increase in exploration activities and the initiation of significant new production programmes. Although production is estimated to have declined slightly in 2006 compared to 2005, increased investment will help meet the expected increased demand in the years to come as secondary sources diminish and reactor requirements need to be increasingly met by primary production. However, increasing primary production may take some years as uranium mine development times are lengthy in many jurisdictions.

During 2006, uranium conversion facilities continued to operate in Canada, France, the United Kingdom and the United States. In France, detailed design of a new large-capacity conversion facility was under way in 2006 and could lead to first production by 2010.

In terms of uranium enrichment, the worldwide trend towards the use of centrifuge technology continued in 2006. In the United States, the Louisiana Energy Services National Enrichment Facility (NEF) received an NRC construction and operating licence for its new facility in New Mexico, and development of the American centrifuge by the US Enrichment Corporation continued. In France, AREVA began development of the Georges Besse II facility, which will add significant centrifuge enrichment capacity beginning in 2009. Both NEF and Georges Besse II will employ URENCO enrichment technology.


AREVA, France

Above: Uranium "yellow cake".
Right: Aerial view of the JEB mill and the JEB tailings management facility, McClean Lake, Canada.


Cogema, Canada

Nuclear safety and regulation

Overall, the safety performance of nuclear power plants in OECD countries continues to be excellent, as reflected in a number of published performance indicators. The current safety record is built upon a mature industry, a robust regulatory system and a strong foundation of research. There is a general consensus that safety assessment and research can improve the efficiency and effectiveness of a regulatory system by helping to identify the items most important to safety and by anticipating future regulatory challenges, thus allowing resources to be focused on the most significant concerns.

Licensing new technologies and designs is now being recognised as a short-term challenge given recent developments in energy policies. OECD countries are promoting several initiatives to improve the efficiency of the design review of new nuclear power plants. The initiatives seek to enhance nuclear safety worldwide, by promoting convergence on safety practices and by combining the expertise of participating regulatory authorities. The aim is to achieve consensus on safety matters, which will support national regulatory decisions while expediting and improving the safety review of new designs and technologies.

In the meantime, the number of nuclear power plants reaching their initial design life is increasing and license renewal continues to be adopted in many countries. OECD countries have implemented ageing management based on state-of-the-art technology, and for regulatory authorities, it is important to review the adequacy of ageing management methods applied by the operators, based on reliable technical evidence. These countries have taken initiatives to establish databases and knowledge bases on the most important ageing mechanisms, with the goal of continuing to improve practices for ageing management.

Other safety issues are also being closely monitored. In 2006, a small number of significant events took place, drawing attention to failures on electrical and protection systems. These failures illustrate the continuing need to respond to operating experience and to implement an appropriate and timely corrective action programme. Nuclear regulatory authorities and nuclear safety institutions have been active in revealing and resolving issues in this field.

Cogema, Canada

Radiation measurements. Above: at McClean Lake, Canada. Below: at Saclay, France.

A. Gonin, CEA, France

Radiological protection

Many countries are considering the construction of new nuclear reactors and much can be learnt from experience with the current generation of power plants, including the identification of trends and good practice in the radiological protection of workers and the public. These experiences can, in turn, be translated into various types of design targets for such things as occupational exposure from operation and maintenance activities, and public exposure from operation and effluent releases. These design targets will influence not only the physical design of new plants, but the processes and procedures that they will use for operation, maintenance and eventually decommissioning activities. As such, the assessment of current trends and experience, with new build in mind, is increasingly being considered at the utility/operational level and at the regulatory/policy level as well. This will have an effect on designs and plans for Generation III+ and Generation IV reactors.

Assessing experience and establishing design targets are also strongly influenced by another current trend in radiological protection: that of stakeholder involvement in radiological protection decision making. As governments have increasingly recognised their citizens' desire to become actively involved in decisions affecting the management of public and environmental risks, there has been an increasing need to assess how decisions are taken, and to find appropriate mechanisms for the governance of such risks in our modern, information-driven society. In many cases, this has required the modification of organisational structures and procedures to accommodate input from stakeholders. A key example is the process that has been used to develop new general recommendations from the International Commission on Radiological Protection (ICRP). Until 1999, the development of ICRP recommendations was done in a very closed fashion, with experts discussing and developing among themselves "the best approaches" to radiological protection. This process was opened up to broad public consultation in 1999, and although this has somewhat prolonged the development stage of the Commission's new recommendations (now due to be finalised in early 2007), there is consensus that this new process will lead to more broadly understood, accepted and applicable ICRP recommendations than in the past. This process seems to have opened in an irreversible way, and may well become a "procedural benchmark" for the development of other international and national standards and regulations.

Another area affected by stakeholder participation is emergency planning and preparedness. Since the Chernobyl accident, significant efforts have been made, both nationally and internationally, to improve response capabilities to accidents. Broadly, this work has focused on the urgent phase of such accidents, addressing for example communications and data management strategies to best serve the needs of decision makers. More recently, and based on 20 years of experience addressing the effects of the Chernobyl accident, governments have begun focusing on planning for later phases of accident situations. Growing experience from all of the Chernobyl-contaminated areas has indicated that the complexity of these situations can only be addressed through pluralistic discussions and actions directly involving affected stakeholders. These lessons are beginning to affect aspects of emergency planning and preparedness for nuclear and radiological incidents, as well as for malevolent acts.

Radioactive waste management

In May 2006 the second review conference of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management took place in Vienna, Austria under International Atomic Energy Agency (IAEA) auspices, and closely examined the waste management programmes of 41 countries worldwide. It was agreed that progress had been made in all areas of radioactive waste management, including the management of spent fuel, decommissioning waste and disused sealed sources.

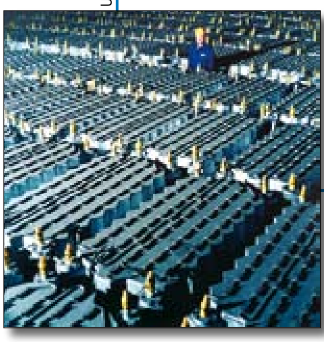
In terms of geological disposal, public attention is still focused on the Yucca Mountain project in the United States and on the ONKALO Facility in Finland, which are both progressing, albeit with some delays in the case of Yucca Mountain. However, at the same time there has also been considerable progress on other, less advanced programmes.

In France, the Planning Act Concerning the Sustainable Management of Radioactive Materials and Waste was issued, updating the 1991 Bataille law which had provided for research to be carried out along three axes (long-term storage, transmutation and geological disposal) over a 15-year time frame. The Act requires an application for a deep geological repository to be submitted by 2015 and for the repository to be commissioned by 2025. Retrievability is a key feature of this repository. The new law also institutes a formal national radioactive waste management plan and prescribes that by 2013 a decision should be made for graphite and radium-bearing waste, a category of low-level, but long-lived waste.

The Belgian programme made an important step forward when the Belgian government decided in June that low- and intermediate-level, short-lived waste will be disposed of in a surface repository in Dessel. This municipality – as well as the other candidate municipality of Mol – had been engaged in a participatory process with the Belgian waste agency ONDRAF/NIRAS and had expressed its willingness to host such a facility. The partnership arrangements will be maintained throughout the process of repository design.

Following the publication by the UK Committee on Radioactive Waste Management (CoRWM) of its final report and recommendations for the long-term management of long-lived waste in June, the UK Environment Minister outlined the government's policy in this area in October, closely echoing the findings of the CoRWM. The government confirmed that geological disposal should be the end-point for such wastes and that any siting decisions should be taken based upon open and transparent partnerships with potential host communities. An important change to institutional arrangements will be the transfer of the implementer's responsibility from UK

UKAEA, United Kingdom



Examples of decommissioning activities carried out in the United Kingdom.

NIREX to the Nuclear Decommissioning Authority (NDA). A successor body to the CoRWM will provide independent scrutiny and advice to the government.

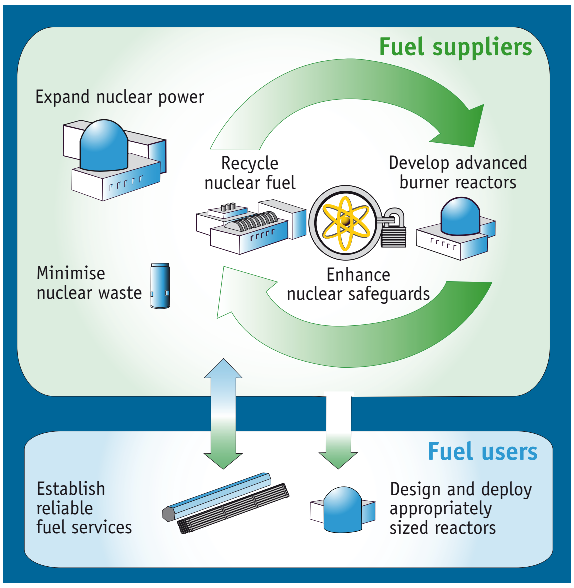
Finally, important legal decisions have been taken which strengthen the waste management programmes in Germany and Switzerland. For the Konrad repository in Germany, the Lower Saxony administrative court denied the request for an injunction, thus opening the door for the utilisation of the Konrad mine as a repository for non-heat-generating waste. In Switzerland, the Federal Council approved the findings of the *Entsorgungsnachweis* project, thus confirming that construction of a deep geological repository for high-level waste, spent fuel and long-lived, intermediate-level waste is in principle feasible in Switzerland. This decision paves the way to begin site selection once the related criteria have been specified.

The only operating geological repository worldwide, the WIPP (Waste Isolation Pilot Plant) in New Mexico, which has been receiving long-lived transuranic radioactive waste for five years, was recertified by the US Environmental Protection Agency (US-EPA). The recertification is a mandatory review of the WIPP's long-term safety and performance to ensure that it continues to meet safety requirements based on the most accurate and up-to-date information available. The US-EPA reviewed information from operational changes and emplacement experience, site characterisation data, and updated estimates of the waste inventory. The decision also took into consideration an updated performance assessment provided by the US Department of Energy.

Nuclear science

One of the key issues in the development of advanced nuclear systems is the choice of materials. This is true for structural materials as well as for materials used in the development of advanced nuclear fuels. Many different aspects have to be taken into account, for example temperature, radiation and corrosion resistance, as well as radiation activation concerns. As a complement to experimental activities, there are currently a number of national and international scientific projects devoted to the development of computer models simulating the behaviour of structural and fuel materials under different conditions. The computer models aim at developing multi-scale numerical tools to simulate the effects of irradiation on mechanical and corrosion properties of materials, starting from basic physics principles.

Recent initiatives, such as the US Global Nuclear Energy Partnership (GNEP), have generated renewed interest and subsequent scientific studies in, for example, areas related to the back end of the fuel cycle and to the development of smaller or modular nuclear reactors. Different types of nuclear fuel recycling schemes are being studied with the goal of developing a more efficient fuel cycle with improved proliferation resistance. Another advantage of advanced recycling schemes is that they produce less nuclear waste. The studies involve both the chemistry of the fuel separation processes and the potential to burn (transmute) transuranic elements in fast reactors or in dedicated, accelerator-driven, sub-critical reactors.



The Global Nuclear Energy Partnership focuses on expanding nuclear power and establishing partnerships between fuel suppliers and fuel users.

Nuclear law

NEA members are striving to minimise legal impediments to the safe use of nuclear energy and to develop and harmonise legislation governing the peaceful uses of nuclear energy. To that end, they continue to search for solutions to overcome nuclear operators' inability to obtain private insurance coverage for certain third party liability and material damage risks they are legally obliged to assume; to determine whether the risks associated with radioactive sources and nuclear fusion installations should be covered by special nuclear liability and compensation regimes; to ensure that the use or transport of small quantities of nuclear substances are not subject to an overly burdensome liability and compensation regime; to assess the impact of international conventions outside the nuclear field on nuclear activities; to facilitate the development and implementation of nuclear safety assistance programmes with non-members and to assist selected non-members in adopting domestic nuclear legislation based upon internationally accepted principles.

They are also striving to ensure that adequate and equitable compensation is made available to victims who suffer injury or damage as a result of a nuclear incident. Those members who adopted the Protocols to amend the Paris and Brussels Supplementary Conventions in 2004 continue to work actively towards their ratification and implementation into national legislation. Other members are on their way to ratifying the 1997 Convention on Supplementary Compensation for Nuclear Damage, while still others are examining the benefits of adhering to the 1997 Protocol to Amend the Vienna Convention or are considering amending their national legislation to reflect the provisions of these instruments.