Nuclear Power in 2007

Nuclear energy development

At the end of 2007, a total of 346 reactors were connected to the grid in OECD countries constituting some 83% of the world's total nuclear electricity generating capacity, and about 23% of the total electricity supply in the OECD area. During 2007, one reactor was restarted in the United States and none were shut down. Construction was initiated on three reactors (one in France and two in the Republic of Korea), and construction resumed on one reactor in the United States.

There are significant differences in nuclear energy policy in OECD countries, some of which (e.g. Austria, Belgium, Germany, Italy, Spain and Sweden) have official moratoria or phase-out policies. However, the fact that nuclear power can produce competitively priced, base-load electricity that is essentially free of greenhouse gas emissions and can enhance security of energy supply has led several governments to conclude that nuclear energy is a necessary part of the energy mix. This is perhaps best exemplified by the October 2007 Resolution of the European Parliament which characterised nuclear energy as "...indispensable if basic energy needs are to be met in Europe in the medium term." In 2007, plans to increase nuclear capacity gained momentum in several OECD countries:

- In Canada, an Environmental Assessment of Bruce Power's proposal to build new reactors (approximately 4 000 MWe in total) in Ontario was initiated. A feasability study was undertaken for building a 1 085 MWe advanced CANDU reactor in the province of New Brunswick. In Alberta, the construction of two advanced CANDU reactors was proposed to help extract oil from the tar sands.
- In Finland, construction of the Olkiluoto-3 European pressurised water reactor (EPR) continues. Environmental impact assessments of plans to build an additional unit at Olkiluoto and at Loviisa were initiated, and intentions to build another reactor at an as yet undetermined location were announced.
- In France, construction of a 1 630 MWe EPR began near Flamanville in the Basse-Normandie region in December 2007. *Électricité de France* (EdF) intends to replace its present reactors with EPRs beginning in 2020, based on experience with the EPR unit under construction in Flamanville.
- In Japan, construction of the Tomari-3 and Shimane-3 reactors continued, as did preparations to restart the Monju fast reactor. In parallel, the government approved a long-term plan to enhance security of energy supply by placing greater importance on developing nuclear power, a nuclear fuel recycling system and fast breeder reactors.
- In the Republic of Korea, construction of the Shin Wolsong-1 reactor officially began and construction of the first of two reactors (APR-1400s) at Shin Kori continued. Current plans call for the construction of an additional two APR-1400 units at Shin Ulchin beginning in 2015.

2007 Nuclear Data Summary (as of 31 December 2007)

	Operational reactors	Installed capacity (GWe net)	Uranium requirements (tonnes U)	Nuclear share of electricity production (%)
Belgium	7	5.8	906	54.1
Canada*	20	12.5	1 700	15.6
Czech Republic*	6	3.5	664	31.5
Finland	4	2.7	489	29.0
France	59	63.3	7 184	76.8
Germany	17	20.4	3 400	23.2
Hungary	4	1.8	407	37.2
Japan*	55	47.1	8 792	34.2
Mexico	2	1.4	356	4.4
Netherlands*	1	0.4	65	3.1
Republic of Korea*	20	16.8	3 600	38.9
Slovak Republic	5	2.0	475	54.9
Spain	8	7.5	1 283	17.8
Sweden*	10	9.0	1 600	50.3
Switzerland	5	3.2	318	40.6
United Kingdom*	19[a]	10.2[a]	2 165	19.5
United States*	104	100.0	22 890	19.4
Total (OECD)	**346**	**307.6**	**56 294**	**22.7**

* 2006 data. a) 2007 estimates.

- In the Slovak Republic, the completion of the construction of two reactors, stopped in 1992, has been confirmed and consideration is being given to building additional units.
- In Switzerland, three energy companies announced the creation of the Resun joint venture which intends to replace the Beznau and Muhleberg reactors with plants of up to 1 600 MWe by 2020.
- In the United States, the Tennessee Valley Authority restarted the Browns Ferry-1 plant (shut down in 1985) and announced that it would complete construction of the Watts Bar-2 nuclear power plant (construction suspended in 1988). The Nuclear Regulatory Commission (NRC) accepted for review the South Texas Nuclear Project (two advanced boiling water units with a combined capacity of 2 700 MWe), the first of several anticipated combined construction and operating licences.

More generally, the governments of the Czech Republic, Hungary and Mexico are considering building new units, and the governments of Poland and Turkey are moving forward with plans to introduce nuclear power. The government of the United Kingdom conducted a national consultation on the role of nuclear power in a low carbon economy.

In non-OECD countries, three new units came on line in 2007 and construction of another four began. Plans were initiated for robust expansion of nuclear electricity generating capacity in China, India, the Russian Federation and South Africa, and consideration is being given to either increasing existing capacity or to introducing nuclear energy in a growing number of countries, including Argentina, Bulgaria, Indonesia, Kazakhstan, Lithuania, some of the Persian Gulf States, Romania and Vietnam.

Initiatives to develop international nuclear fuel cycle programmes also made headway in 2007. The Global Nuclear Energy Partnership (GNEP) proposed by the United States and designed to aid the expansion of the peaceful uses of nuclear energy through enhanced safeguards, international fuel services and advanced technologies (including reprocessing and fast reactors) grew to 19 members in late 2007 (Australia, Bulgaria, Canada, China, France, Ghana, Hungary, Italy, Japan, Jordan, Kazakhstan, Lithuania, Poland, the Republic of Korea, Romania, the Russian Federation, Slovenia, Ukraine and the United States). The International Enrichment Centre initiative, a partnership between the Russian Federation and Kazakhstan under International Atomic Energy Agency (IAEA) supervision, also aims to enhance non-proliferation by allowing international partners access to enriched nuclear fuel services without having to deploy the technology locally. Armenia joined the partnership in late 2007. Successful deployment of these programmes and fast reactors could lead to significant changes in global nuclear power development and nuclear fuel cycle activities.

Uranium production, conversion and enrichment

Preliminary data indicate that in 2006 uranium was produced in just five OECD countries, one of which produced only small amounts as part of mine remediation activities. However, Canada (25%), Australia (19%) and the United States (5%) accounted for almost half of world production. Production in OECD countries amounted to approximately 19 700 tonnes of uranium (tU) in 2006 and is expected to increase slightly in 2007. Production in OECD countries accounted for only about 30% of the uranium requirements in the OECD area, with the remainder being met by imports and secondary sources (excess commercial inventories for example). A complete picture of the uranium market will be available in 2008 when *Uranium 2007: Resources, Production and Demand* is published jointly by the NEA and the IAEA.

Beginning in 2001, the spot price of uranium began to rebound from historic lows of about USD 18/kgU to levels not seen since the 1980s. In 2007, the spot price rose dramatically to a high of USD 354/kgU in June before declining to USD 235/kgU in December. High prices have stimulated increased exploration that has already resulted in significant new discoveries, but temporary difficulties at operating mines have resulted in reduced output. Increasing demand combined with reduced production and dwindling inventories have all contributed to strengthening the market. Purchases by speculators are also considered to have been an important factor, particularly in the swift rise in price in early 2007. The spot market price has gone through more rapid and significant changes in 2007 than it has in decades, creating great interest in the market and injecting much-needed investment into the industry.

During 2007, uranium conversion facilities continued to operate in Canada, France, the United Kingdom and the United States. CoverDyn completed upgrades and expanded capacity at its plant in the United States; AREVA invested in a new, large-capacity conversion facility in France that is expected to begin production by 2010; and Cameco signed an agreement with Kazatomprom that could lead to the development of a new conversion facility in Kazakhstan.

In terms of uranium enrichment, in 2007 construction progressed at two new centrifuge plants using URENCO technology: AREVA's Georges Besse II facility in France and Louisiana Energy Services' National Enrichment Facility (NEF) in the United States. The US Enrichment Corporation received a licence from the NRC and is progressing on its demonstration of the American centrifuge design. AREVA announced plans to apply for a licence and to build a centrifuge facility in the United States. GE-Hitachi Nuclear Energy continued development of the Australian SILEX laser enrichment technology while China and Japan continued development of domestic centrifuge enrichment facilities.

Nuclear safety and regulation

In 2007, the safety performance of nuclear power plants in OECD countries remained at a very high level, as in previous years. The main elements of this achievement are 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.

The number of nuclear power plants reaching their initial design life is increasing and licence renewal continues to be an approach adopted in many OECD countries. The NEA continues to support regulatory authorities in their review of the adequacy of ageing management methods applied by the operators, based on state-of-the-art technology and reliable technical evidence.

In 2007, a significant earthquake took place in Japan near the 7-unit Kashiwazaki Kariwa nuclear power plant. Though the impact on plant safety has been negligible, the plant will remain shut down until exhaustive examinations are completed. The lessons learnt from this analysis will be addressed by the international community to discuss potential improvements to face external events. This event illustrates the continuing need to respond to operating experience and to implement an appropriate and timely corrective action programme. Nuclear regulatory authorities and nuclear safety research institutions have been active in revealing and resolving issues in this field.

Licensing new technologies and designs is now being recognised as a priority 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 and to share experience related to the regulation of new reactors. 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 improving and expediting the safety review of new designs and technologies.

Radioactive waste management

After phases of reorientation and extensive consultancy processes on radioactive waste management options, important decisions have been taken in some OECD countries, providing new stable direction for further developments.

The government of Canada formally selected Adaptive Phased Management as Canada's approach for the long-term stewardship of its used nuclear fuel. By this decision, the government followed the recommendation of the Canadian Nuclear Waste Management Organisation (NWMO), which proposed this plan in November 2005 after a three-year study which engaged thousands of citizens in every province and territory of Canada. In accordance with the Canadian Nuclear Fuel Waste Act, the NWMO is now responsible for implementing the government's decision.

In the United Kingdom, the government had sought advice from an independent group, the Committee on Radioactive Waste Management (CoRWM), on its future waste management policy. Following the publication of the CoRWM report in 2006, the government launched a public consultation on how to manage higher-level radioactive waste safely. The summary and analysis of responses to this broad public consultation process, which was meant to ensure that final decisions reflected all interests, concerns and best practice, have been published. The consultation responses indicate support for managing higher-activity radioactive waste in the long term through geological disposal, as recommended by the CoRWM as the best available option.

The European Union Council also gave new momentum to the waste management efforts of its members by launching a High-level Group on Nuclear Safety and Waste Management and a European Nuclear Energy Forum. Addressing waste management issues will be a major activity of both institutions.

With several countries now firmly committed to geological disposal of the higher-activity and longer-lived wastes, the outlook for progress in the disposal area is now much stronger than in the past. This was confirmed at the International Conference on Geological Repositories (ICGR07), held in Berne, Switzerland, on 15-17 October 2007. Participants discussed the current status of affairs in long-term waste management on a high political level and showed a clear commitment from all major waste programmes to geological disposal. They noted that there has been progress in recent years and that some programmes have become more mature, refocused or legally tied to clear schedules. While safety remains the first priority, local acceptance of the site and national acceptance of the programme are key, and both need to be secured for the long term.

On the technical and project levels, tangible progress has been made in some of the most advanced geological repository programmes. The construction of underground exploratory facilities on repository sites – or at least at designated areas – has moved forward in France at the Bure site and in Finland at the Olkiluoto site. Following the final rejection of lawsuits by the highest administrative court in Germany, the construction and operating licence for the Konrad geological repository for low- and intermediate-level waste has been confirmed and technical work started to convert the former iron ore mine into an active repository. In Sweden, SKB submitted its latest research programme which should lead to site selection of a final repository in 2009. For its part, the US Department of Energy is preparing to submit the Yucca Mountain license application to the regulatory authorities in mid-2008.

Radiological protection

Important changes in the nuclear field are beginning to take shape, and radiological protection is no exception. A major step forward was taken with the approval in March of the new general recommendations of the International Commission on Radiological Protection (ICRP), which have been published as ICRP Publication 103. The revision of the international Basic Safety Standards, in which eight international organisation are participating, are now well under way. Finally, though outside the production of nuclear energy, there are radiological protection challenges associated with the increasing use of medical exposures.

In terms of new developments, the general recommendations of the ICRP adopted in 2007 cover all exposures to radiation, from both natural and artificial sources. Based on the excellent experience with the "as low as reasonably achievable" (ALARA) approach to managing occupational exposures and effluent releases, and further driven by increasing participation of stakeholders in risk-

Monitoring radioactivity.

related decision-making processes, approaches to managing what the ICRP now calls "Emergency and Existing Exposure Situations" has increasingly moved towards optimisation. This brings a certain harmony to the management of any type of exposure, which currently are not all managed by focusing on the optimisation of protection. This means that, following the precautionary principle, there is no pre-determined end-point or level below which it is generically seen as inappropriate to further reduce exposures. Instead, situation-specific aspects are assessed in order to identify and implement the most effective protection for the circumstances at hand. The new recommendations do, however, continue to propose using dose limits to ensure that individuals, either workers or members of the public, are not overly exposed. Governments have begun looking into how Publication 103 may affect national regulation and are developing plans to implement changes where appropriate.

The revision of the 1996 International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources (BSS) has been undertaken by eight international organisations: the International Atomic Energy Agency (IAEA, which has overall responsibility for the BSS revision), the OECD Nuclear Energy Agency (NEA), the International Labour Organisation (ILO), the World Health Organisation (WHO), the Pan-American Health Organisation (PAHO), the Food and Agriculture Organisation (FAO), the European Commission (EC) and the UN Development Programme (UNDP). In addition to the overall revision of the standards, the participating organisations will also be looking into how the recently adopted ICRP general recommendations may impact the BSS. The target approval date of the revised BSS by the IAEA Board of Governors is September 2009; approval by the co-sponsoring organisations is planned to take place in parallel.

Under social pressure and rapid technical evolution, the medical use of radiation is growing and is the largest man-made source of radiation exposure. The increasing use of medical radiation applications, and the availability of rapidly changing new technologies in medical imaging and radiotherapy have resulted in radioprotection issues not always being fully taken into account during the introduction or planning of apparatus or procedures. This has increased the risk of serious accidental radiation overexposure of patients due to human, organisational or technological failures, which are reported. While arrangements are being put in place to minimise the risk of such accidents, there will be an ongoing need to devote resources to ensure that radiation protection requirements and optimisation proceed in parallel with technology development and implementation, and that tools for preventing unplanned medical overexposures are upgraded.

Nuclear science

Demand continues to increase from the nuclear research, industry, safety and regulation communities to obtain good knowledge of the uncertainties associated with different calculated/modelled reactor parameters such as criticality, radiation load on the main reactor components and neutron/gamma ray flux. This information is especially important for the estimation of safety margins as a better understanding of, and confidence in, these margins could have a significant economic impact.

To help meet the demand for a better estimation of modelling and simulation uncertainties, nuclear data library producers are making efforts to include uncertainty information in their data libraries in the form of covariance matrices. Methodologies have also been developed and/or are under development in many countries to quantify computational biases and their associated uncertainties. The methods used are mainly based on linear perturbation theory to calculate the sensitivity coefficients and to propagate these sensitivities, using the basic data covariance matrices, to the final reactor parameters.

Nuclear law

OECD countries continue to strive to minimise legal impediments to the safe use of nuclear energy and to develop and harmonise legislation governing the peaceful uses of nuclear energy. Ensuring that adequate and equitable compensation is made available to victims who suffer injury or damage as a result of a nuclear incident occurring at a nuclear installation or during the transport of nuclear substances is still a primary aim. Those member countries which adopted the Protocols to amend the Paris and Brussels Supplementary Conventions in 2004 are actively working to implement the provisions of these protocols in their national legislation. Other OECD member countries are examining the benefits of adhering to the 1997 Protocol to amend the Vienna Convention, and still others are evaluating the advantages of adhering to the 1997 Convention on Supplementary Compensation for Nuclear Damage. Several of these countries are searching for solutions to overcome nuclear operators' inability to obtain private insurance coverage for certain third party liability risks that they are legally obliged to assume under these conventions.

Other important issues concern the impact of international conventions outside the nuclear field on nuclear activities; ensuring that the use or transport of small quantities of nuclear substances are not subject to an overly burdensome liability and compensation regime; identifying legal and economic factors that may impact nuclear emergency decision making; facilitating the development and implementation of nuclear safety assistance programmes with non-members; and assisting selected non-members in adopting domestic nuclear legislation based upon internationally accepted principles.