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Contents

Facts and opinions

NEA updates

News briefs

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The OECD Nuclear Energy Agency (NEA) is an intergovernmental organisation established in 1958. Its primary objective is to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes. It is a non-partisan, unbiased source of information, data and analyses, drawing on one of the best international networks of technical experts. The NEA has 28 member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the NEA. A co-operation agreement is in force with the International Atomic Energy Agency.

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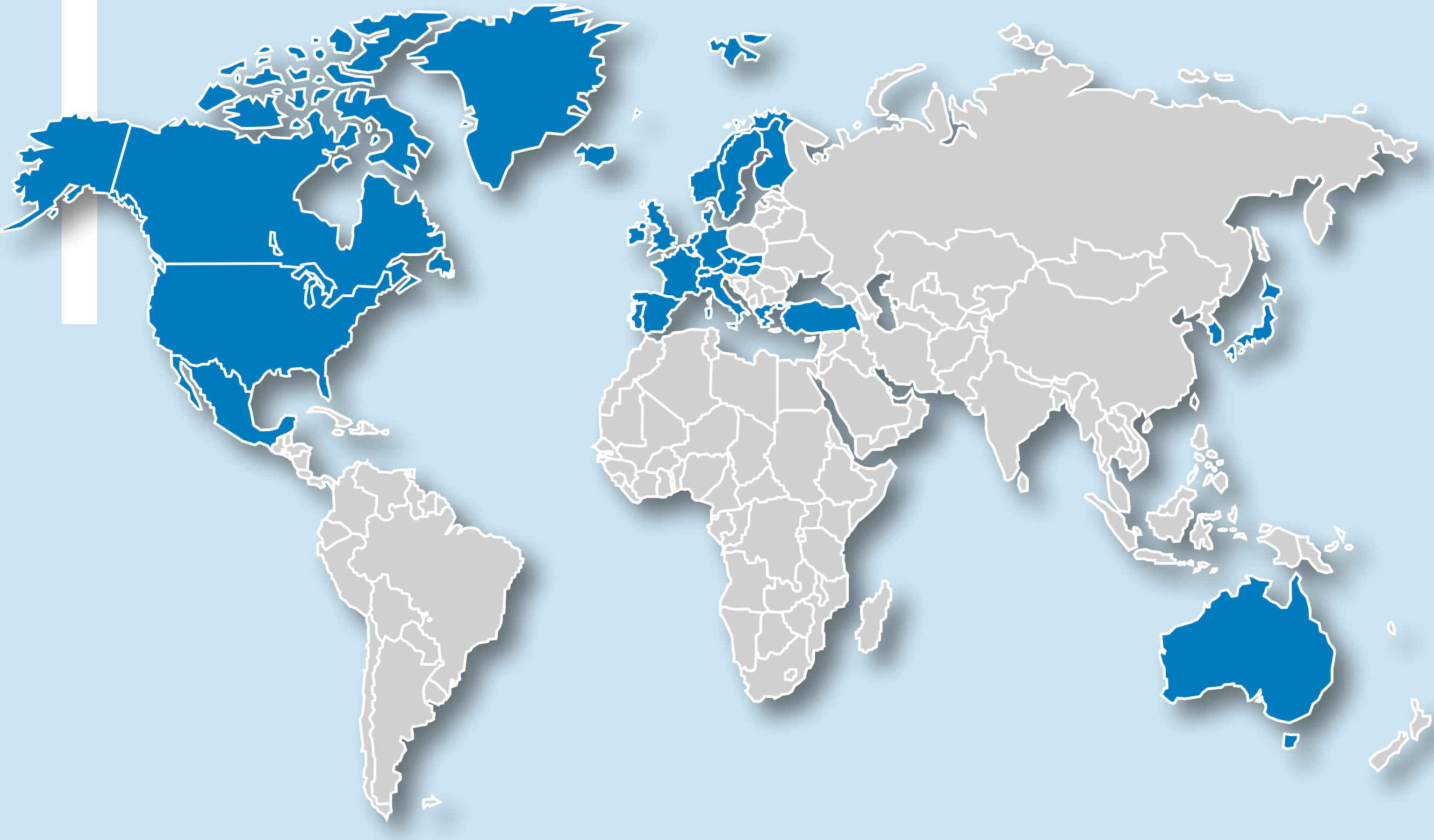
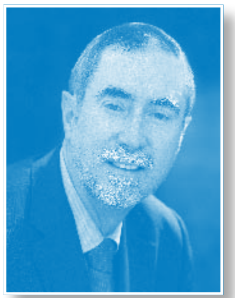
Cover page photo credits: Caorso nuclear power plant, Italy (photo: SOGIN), advanced test reactor (photo: INEEL), NRU research reactor (photo: AECL), Richland disposal facility for radioactive waste, Washington, USA (photo: US Ecology, Inc.). Page 3 photo credit of Luis Echávarri (M. Lemelle, France).

NEA member countries



New nuclear challenges: the Agency at the forefront



Over the past six months, interest in nuclear energy has continued unabated. Many countries have expressed their intention to launch nuclear programmes; the European Commission has adopted a multibillion euro Plan for New Energy Investment, including the objective that the first prototype of a Generation IV nuclear reactor should be in operation in 2020.

Investments in nuclear installations have to be financed – this could be the main hurdle in the current financial and economic crisis. The question of risk sharing among stakeholders and the role of government are keys, as the just-released publication *The Financing of Nuclear Power Plants* outlines. The article on page 4 summarises its main findings.

Funding decommissioning should be considered at the outset of a nuclear project. Cost estimation for decommissioning has become a requirement in most NEA countries and some good practices can already be identified, as outlined in the article on page 12.

Construction of new reactors also needs a foreseeable regulatory framework. The Multinational Design Evaluation Programme (MDEP), which brings together regulators of the main nuclear countries, aims at facilitating common approaches. As the Technical Secretariat of the MDEP, the NEA organised a major conference in September where the outcomes of MDEP work were shared with vendors, standardisation bodies and non-MDEP members. An overview of current MDEP activities is provided on page 18.

A major step forward has been taken in European Union regulation with the adoption of the "Council Directive establishing a Community framework for the nuclear safety of nuclear installations". This is a breakthrough considering that the initial project had been circulated in 2003, as the article on page 20 explains along with the innovations contained in this new legislation.

At the crossroad of regulation and operation, radiological protection is still high on the NEA agenda. The NEA issued as far back as 50 years ago the first basic norms for the radiological protection of workers. After the Chernobyl accident, the Agency laid the foundation of the International System on Occupational Exposure (ISOE). The new report on *Work Management to Optimise Occupational Radiological Protection in the Nuclear Power Industry* and its main lines are described in the article on page 8.

While radiation exposure should be minimised, a recent crisis has reminded us that sources of ionizing radiation can also be vital for human health, notably through medical applications. On page 23, the news brief on the medical radioisotopes shortage explains the situation and provides a summary of the NEA contribution to help resolve this challenge.

While medical radioisotopes have recently sparked specific public concerns, nuclear waste management has certainly been one of the most constantly raised issues over the past decades. The article on page 15 recalls that stakeholder confidence and participation in selecting the right sites are becoming an essential part of the process.

The public is not always widely aware that nuclear technology, for power or medical purposes, contributes to making many of our daily activities possible while also limiting greenhouse gas emissions. The extract of the NEA's *Nuclear Energy Data 2009* on page 25 provides key figures not be forgotten, especially in the context of the UN Climate Change Conference (COP-15) being held in Copenhagen in December.

Luis E. Echávarri
NEA Director-General

The financing of nuclear power plants

by M. Taylor*

Existing nuclear generating capacity plays an important role in providing secure, economic and low-carbon electricity supplies in many OECD countries. At the same time, there is increasing recognition that an expansion of nuclear power could play a valuable role in reducing future carbon dioxide emissions. However, in recent years only a handful of new nuclear power plants (NPPs) have been built in just a few OECD countries. An important reason for this is the challenges associated with financing the construction of new NPPs.

The just-published NEA report entitled *The Financing of Nuclear Power Plants* examines these challenges. In addition, recognising that any expansion of nuclear power programmes will require strong and sustained government support, the report highlights the role of governments in facilitating and encouraging investment in new nuclear capacity.

The major challenges to financing NPPs

While there are many common characteristics between building new NPPs and building other types of large infrastructure, there are a number of special characteristics and circumstances which make investment in new NPPs different in several important respects. These include:

- the high capital cost and technical complexity of NPPs, which present relatively high risks during both construction and operation;
- the relatively long period required to recoup investments or to repay loans for NPP construction, which increases the risk from electricity market uncertainties;
- the often controversial nature of nuclear projects, which gives rise to additional political and regulatory risks;
- the need for clear solutions and financing schemes for radioactive waste management and decommissioning, which only governments can formulate;
- the need for NPPs to operate at high capacity factors, preferably under baseload conditions.

The higher capital costs of an NPP mean that its overall economics are more dependent on the cost of capital, or discount rate, which applies to the investment in its construction. With any investment, higher risks demand higher returns. Thus, the cost of capital will depend on potential investors' assessment of the risks involved.

During the previous major expansion of nuclear power in the 1970s and 1980s, many nuclear projects suffered very large construction delays and cost overruns. Moreover, given the lack of recent experience with new NPP construction in most countries, the legacy of such problems increases the risks perceived by potential investors. With high capital costs, any delay during construction will have a significant impact on total costs.

Several different factors could lead to delays in entering operation. As well as technical issues with construction and supply chain risks (including the availability of skilled labour and professional staff), they include legal challenges, regulatory or licensing issues, and political and policy risks.

There are also financial risks during the operating phase. These include fuel costs, electricity market prices, plant reliability and performance, as well as political and policy risks. These risks exist for most power generation projects, but in differing proportions. Table 1 summarises some of the main types of risks involved in investing in a new NPP as well as possible options for mitigating them.

Since most existing NPPs were built, the electricity markets in many OECD countries have been restructured to introduce competition. Whereas in the past utilities building nuclear power plants

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could pass on the costs to electricity consumers, in a competitive market there is no guarantee that electricity prices will provide an adequate return on investment. However, there are some countries and regions where strong, vertically integrated utilities remain, or where electricity price regulation remains in force. Financing new NPPs may prove to be more straightforward in such cases.

Impact of the present financial crisis

The global financial system has recently experienced its worst crisis for several decades, with a number of major banks having failed or requiring large-scale government support. This is having a significant near-term impact on the ability to raise commercial finance for any purpose, including large-scale infrastructure.

Table 1: Main types of risk when investing in a new nuclear power plant

Risk type	Description of principal risks	Primary risk taker(s) and possible mitigation
Design risks	Misspecification of design, or design does not meet specification, possibly requiring redesign during construction, licensing amendments, additional work and replacement equipment.	Owners and/or vendor, according to fault. Avoid first-of-a-kind risks by using established design, use experienced project managers.
Construction and supply chain risks	Delays by contractors or subcontractors in completing on-site work or in supplying equipment; substandard work or equipment, requiring replacement; costs of work or equipment greater than expected; delays in commissioning of plant; etc.	Vendor and/or other contractors, also owners. Use appropriate contractual arrangements, with experienced contractors and established design.
Regulatory and licensing risks	Unexpected delays in obtaining construction and operating licences and permits from national and local agencies; unreasonable delay or failure in renewing operating or other permits during plant operating life.	Owners and government. Need to establish an efficient and predictable regulatory system; risks will be reduced once system is fully demonstrated.
Political risks	Change of government and/or policy towards nuclear: could result in impaired fiscal, financial or contractual arrangements; additional regulatory requirements; forced abandonment of construction or premature closure of operating plant.	Owners and government. Establish a broad political consensus on the role of nuclear power, with clear legal and contractual cover for political risks.
Financial risks	Changes in interest rates and taxes; inability to refinance loans on favourable terms; foreign exchange risks; costs and availability of nuclear liability and other insurance.	Owners. Risk reduction through use of financial instruments; need for government to establish legal framework for nuclear liability.
Natural disasters, *force majeure*	Earthquakes and other natural disasters (according to region), which could cause damage to plant and forced outages; security risks and threats of terrorism, which could add to costs.	Owners. Licensing and design requirements for seismicity, etc.; insurance; avoid politically unstable regions; physical security measures.
Operating risks	Equipment failures and incidents during operation, leading to reduced electrical output, unplanned outages, additional repairs and maintenance, etc.; delays and incidents during planned maintenance and refuelling.	Owners, also vendor and/or other contractors (including warranties). Use experienced contractors, skilled operators, proven equipment design.
Fuel supply risks	Delays in the supply of fabricated fuel elements resulting in reduced electrical output or even closure; fuel quality issues resulting in handling difficulties; unexpected large increases in fuel cycle costs.	Owners. Long-term fuel cycle contracts; use competing suppliers; government may need to establish nuclear agreements with supplier countries.
Electricity market and carbon-trading risks	Failure to be dispatched by system operator; unexpectedly low electricity prices in market; failure of customer for power purchase or off-take contract(s); unfavourable changes in electricity market regulation or carbon-trading regime.	Owners. Electricity market with suitable provisions for long-term contracts, price setting, dispatch, etc.; stable system for carbon trading or pricing.
Waste management and decommissioning risks	Failure to establish national facilities in expected time frame with inability to move spent fuel and waste off site; higher than expected costs due to policy uncertainty and delays; increased requirements for decommissioning cost provisions.	Owners and/or government. Need for government to establish clear and consistent policies, and suitable measures to implement them.

Public finances are also highly stretched in many OECD countries. At the same time, the resulting economic slowdown is reducing demand for energy and electricity, making investment in any energy infrastructure less attractive. Oil and natural gas prices have also fallen, reducing short-term incentives to invest in non-fossil energy sources, including nuclear power.


Tomari Nuclear Power Plant, Japan

Demand for new nuclear power plants continues to be strong, particularly in Asia.

Electricity market risks can be mitigated by long-term agreements with large consumers or electricity distributors. In some cases, direct involvement of such consumers in the structure of the project may be an attractive option. Governments have a role here in that they set the regulations which govern electricity markets, and which if badly designed can unduly favour short-term investments.

It is difficult to estimate the precise effect of the current situation on nuclear investments in the short to medium term, since most prospective nuclear projects are not yet firm commitments and their construction schedules remain subject to other uncertainties. In the longer term, the case for investment in new NPPs, and the obstacles to that investment, will remain fundamentally unchanged. The main concern is that important investment decisions will be delayed. Given the long timescales needed for nuclear projects, this could mean that short-term options will have to be adopted when economic growth and energy demand pick up.

Main issues and findings

It is clear that strong and consistent government support is an essential prerequisite for initiating or expanding any nuclear power programme, as part of a long-term national energy strategy. Given the long time frame involved in nuclear power projects, a broad-based political consensus is likely to be needed. Otherwise investors will be open to the risks of sudden policy shifts as governments change, potentially jeopardising their investment.

Many of the risks presented by the special factors noted earlier can be mitigated by appropriate government actions. Other risks, including those inherent in any large construction project, can be transferred to or shared with other parties by appropriate structuring of the project, in order to reduce the risks to investors.

Specifically, governments need to put in place an efficient regulatory framework, which allows appropriate opportunities for public involvement but allows clear and definite decision making within a reasonable timescale. Additional legal frameworks dealing with liability issues, radioactive waste management and decommissioning are also necessary. Furthermore, governments have an important role in providing public information and leading national debate on the role of nuclear power.

Another important factor affecting electricity markets is the cost of carbon dioxide (CO_2) emissions. Doubts about long-term political commitment to such policies and carbon price uncertainty may limit the benefits for nuclear investors. Again, governments may be able to take steps to reduce these uncertainties. Fully recognising the potential role of nuclear power in a new UN agreement to cut CO_2 emissions could be an important step in this regard.

However, it is the construction phase of a nuclear project which is generally considered the most risky for investors. This is especially true for "first-of-a-kind" plants and for new nuclear power programmes. Large amounts of capital must be invested early on, while returns will not begin to flow for some years. Traditionally, construction risk was passed on to electricity consumers through regulated prices, but in liberalised markets this is no longer possible.

To some extent, construction risk can be shared with NPP vendors and other contractors actually building the plant, either through fixed price "turnkey" contracts or through performance-related contract clauses, but in practice contractors have only a limited capacity for such risk taking. Debt investors will also not normally accept such risks.

Thus, in most cases the risks of delays and cost overruns will fall mainly on equity investors. They can only reduce these risks by choosing standardised NPP designs that are already in operation elsewhere, built by experienced and well-managed contractors. This is a possible area for targeted government support to reduce the risk to investors to acceptable levels, at least for a limited number of plants in order to start or restart a nuclear power programme.

Corporate finance is the most likely generally applicable model for new NPPs. Large, financially strong utilities will be best able to finance new NPPs, especially if they are vertically integrated. They will be able to attract loans as required, backed by their existing assets. In countries where such utilities do not exist, the need for direct government support to share in the construction risks is likely to be all the greater.

It appears that there is very little likelihood in the foreseeable future to finance a new NPP by using non-recourse or "project" financing (i.e. using only the NPP project itself as collateral). Even for schemes which include a significant proportion of equity, debt investors are unlikely to be willing to provide significant funding for a nuclear power plant without recourse against the balance sheet of a strong and creditworthy utility.

It is important to note that the financing of an NPP need not remain static over its lifetime, and in particular that refinancing is likely to be possible once the plant has successfully entered operation. At that stage, with construction risks removed and with the plant expected to generate steady revenues over several decades, an NPP could be an attractive investment opportunity for investors with a long-term perspective.

Possible government actions to support NPP financing

Key actions that should be considered by governments that wish to see investment in new NPPs include:

- Provide clear and sustained policy support for the development of nuclear power, by setting out the case for a nuclear component in energy supply as part of a long-term national energy strategy.
- Work with electricity utilities, financial companies and other potential investors, and the nuclear industry from an early stage to address concerns that may prevent nuclear investment and to avoid mistakes in establishing the parameters for new NPPs.
- Establish an efficient and effective regulatory system which provides adequate opportunities for public involvement in the decision-making process, while also providing potential investors with the certainty they require to plan such a major investment.
- Put arrangements in place for the management of radioactive waste and spent fuel, and show progress towards a solution for final disposal of waste. For investors in NPPs, the financial arrangements for paying their fair share of the costs must be clearly defined.
- Ensure that electricity market regulation does not disadvantage NPPs. Long-term arrangements may be necessary to provide certainty for investors in NPPs, reflecting the long-term nature of nuclear power projects.
- Where reducing CO_2 emissions is to act as an incentive for investments in nuclear power, the government may need to provide some guarantees that policy measures will keep carbon prices at sufficiently high levels.

In countries where there are large utilities with the financial strength to invest directly in new NPPs, or where there are well-resourced foreign utilities willing to make such investments, fully commercial financing may be possible. However, in other cases it may prove impossible for a nuclear power plant project to go ahead without direct or indirect public sector financial support, which would reduce the investment risks to acceptable levels.

Public sector financial support could involve supporting a state-owned utility in making nuclear power plant investments, providing support to private sector utilities through loan guarantees, tax credits or other measures, or establishing public-private partnerships. However, governments should ensure that, overall, investment risk remains appropriately shared with the private sector. ■

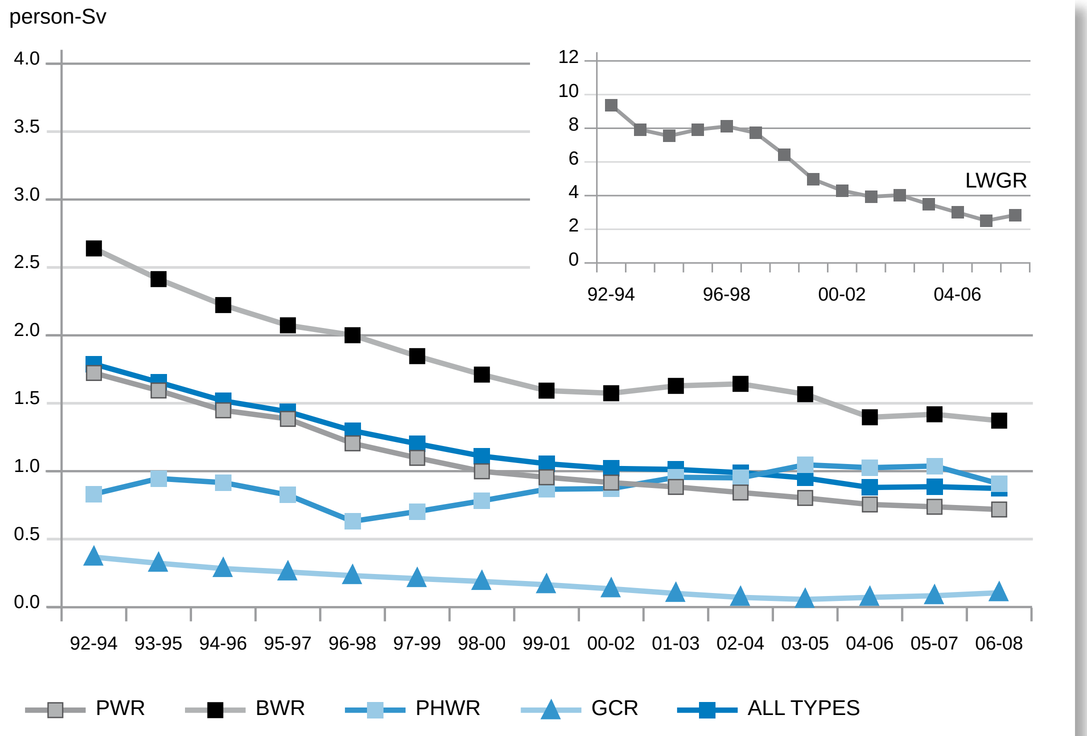
Work management to optimise occupational radiological protection

by B. Ahier*

Occupational exposures at nuclear power plants worldwide have steadily decreased since the early 1990s. Regulatory pressures, technological advances, improved plant designs and operational procedures, "as low as reasonably achievable" (ALARA) culture and information exchange have contributed to this downward trend (see Figure 1). However, with the continued ageing and possible life extensions of nuclear power plants, ongoing economic pressures, regulatory, social and political evolutions, and the potential of new nuclear build, the task of ensuring that occupational exposures are kept as low as reasonably achievable continues to present challenges to radiological protection professionals.

Since 1992, the Information System on Occupational Exposure (ISOE), jointly sponsored by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, has provided a forum for

Figure 1: Annual collective dose per reactor, three-year rolling average,1992-2008



Source: NEA, 2009.

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radiological protection professionals from nuclear power utilities and national regulatory authorities worldwide to coordinate international co-operative undertakings for the radiological protection of workers at nuclear power plants. The ISOE objective is to improve occupational exposure management at nuclear power plants by exchanging relevant information, data and experience on methods to optimise occupational radiological protection.

Key to effective occupational exposure management has been the widespread understanding of the need for careful planning and execution of refuelling and maintenance outages. This approach, referred to *as work management,* stresses the importance of approaching jobs from a multi-disciplinary team perspective, and of following jobs completely through all stages from conception to post-job follow-up. Since the publication of the first ISOE work management report in 1997, this approach has been broadly implemented in the nuclear power industry, and for several years has shown itself to be useful in reducing worker doses and operational costs. However, economic and regulatory pressures have continued to confront the nuclear power industry, while many other changes have also arisen, including evolutions in the radiological protection system, technological advances, social, political and economic changes, and the prospect of new nuclear build. Of no less importance is the ongoing exchange of experience amongst radiological protection professionals.

Although work management is no longer a new concept, continued efforts are still needed to ensure that good performance, outcomes and trends are maintained in the face of current and future challenges. The ISOE programme thus created an Expert Group on Work Management in 2007 to develop an updated report reflecting the current state of knowledge, technology and experience in the occupational radiological protection of workers at nuclear power plants. Published in 2009, the new ISOE report on *Work Management to Optimise Occupational Radiological Protection in the Nuclear Power Industry* provides up-to-date practical guidance on the application of work management principles, thereby contributing to the optimisation of occupational radiological protection. The report presents the key aspects of work management that should be considered by nuclear power plant managers and workers to save time, dose and money, and is supported by recent practical examples from within the ISOE community.

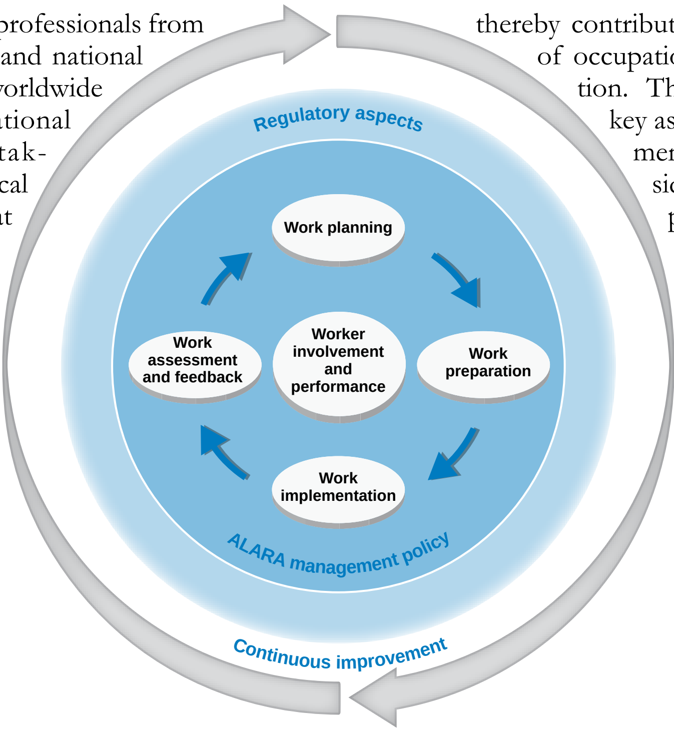

Figure 2: Work management elements and their iterative nature

Principles of work management

The operation and maintenance of nuclear power plants imply the occupational exposure of workers. Experience shows that the optimisation of occupational radiological protection necessitates a coherent and comprehensive work management approach. This approach stresses the importance of managing jobs completely from planning to follow-up in a multi-disciplinary manner which involves all relevant stakeholders. While dose reduction is only one component of this approach, radiological protection personnel are a key component within such teams, and must operate within this context to ensure that occupational exposures are kept ALARA.

Work management measures aim at optimising occupational radiological protection in the context of the economic viability of the installation. Important factors in this respect are measures and techniques influencing i) dose and dose rate, including source-term reduction; ii) exposure, including amount of time spent in controlled areas for operations; and iii) efficiency in short- and long-term planning, worker involvement, coordination and training. Equally important due to their broad, cross-cutting nature are the motivational and organisational arrangements adopted. The responsibility for these aspects may reside in various parts of an installation's organisational structure, and thus, a multi-disciplinary approach must be recognised, accounted for and well-integrated in any work.

Based on the operational experience within the ISOE programme, the following key areas of work management have been identified:

- regulatory aspects;
- ALARA management policy;
- worker involvement and performance;

- work planning and scheduling;
- work preparation;
- work implementation;
- work assessment and feedback;
- ensuring continuous improvement.

The details of each of these areas are elaborated and illustrated in the report through examples and case studies arising from ISOE experience. They are intended to provide all those involved in work management with relevant experience on good practice in the implementation of work management initiatives aimed at optimising occupational radiological protection in the nuclear power industry. The key points of each of these areas are briefly elaborated below.

Regulatory aspects

While it is the licensee's duty, in the first instance, to ensure that a particular operation is safe from the perspective of nuclear safety and radiological protection, this must be done within the applicable regulatory framework. Regulatory frameworks aim to ensure the protection of workers, public and environment from ionising radiation through regulations addressing radiological protection. Such regulation provides for an effective radiological protection infrastructure which includes a "safety culture" shared by those with protection responsibilities from workers through to management. The licensing framework provides one of the means of control available to a regulatory authority. Such frameworks can vary in their level of prescription and can therefore impact the options available to utilities within their approaches to work management. Within this regulatory framework, utilities should also develop and set their own internal radiological protection procedures and develop targets to manage individual and collective exposures.

ALARA management policy

The ALARA approach consists in always questioning whether all that is reasonable has been done to reduce doses in an optimal manner. To foster the practical implementation of this philosophy, it is necessary to create specific organisations for ALARA management, distribute individual and collective responsibilities and establish common rules to be applied. Plant management must put in place a management structure or organisation to ensure that radiological protection is appropriately considered in all jobs performed. In particular, plant management must be willing to support, in policy and budget, a multi-disciplinary team approach to plan, schedule, implement and follow up jobs. Although such structures vary from country to country and from utility to utility, many of the key points of these structures are common and can benefit from experience exchange amongst radiological protection professionals.

Worker involvement and performance

ALARA levels cannot be achieved without worker involvement. It is the worker who is exposed and it greatly depends on the worker himself to reduce the exposure. While certain types of work planning and implementation may be carried out without the feedback of workers, there are many features that can be supported or improved by worker involvement and which can contribute to worker performance. By engaging the worker in the task to be performed, from the planning to the post-job review, the worker is more likely to be motivated to perform the job to the best of his/her abilities. This will be reflected in lower job doses and higher job quality. To ensure the full involvement of workers, conditions should favour the creation and continuation of such involvement and ensure a mechanism for matching individuals and their skill levels with appropriate tasks.

Work planning and scheduling

Work activities must be carefully planned to ensure that radiological protection is optimised. The planning stage is an essential period within which to implement work management actions, incorporate radiological protection criteria and integrate feedback experience and benchmarking to ensure that effective approaches are implemented. Planning and scheduling must recognise not only the sequence of job steps, but also their relationship and their multidisciplinary nature. Key issues in the selection and planning of work include the use of realistic assumptions when deciding upon the necessity for performing work, the selection of only those jobs which are "necessary" to the safe and efficient running of the plant and the implementation of a schedule that is tight but not rushed so as to reduce the risk of rework. Particular attention should be paid to the optimisation of outage duration. The scheduling of jobs in relation to each other, the identification of potential work interferences and hazards in the work zone, and the identification of dose-intensive jobs are critical to the optimal use of resources and job success. In terms of job planning, the effective incorporation of lessons learnt from previous jobs, or from similar jobs performed elsewhere in the nuclear industry, is essential. By concentrating on those jobs which are the most dose-intensive and by making effective use of available experience, work selection and planning activities will be focused and directed.

Work preparation

The success of work greatly depends on the quality of the preparation, which includes all activities performed before and during a job to prepare the site and the work crew. A large amount of preparatory work must be done prior to the outage and should properly reflect the multi-disciplinary nature of the work to be carried out. All efforts to prepare and support the task and its working environment are essential if working conditions and radiological protection are to be optimised. It is crucial to optimise the work site from the perspective of the radiation source term, exposure reduction and work-efficiency improvement. It is essential to understand the radioactive source term in order to select appropriate dose rate reduction techniques such as decontamination and shielding. Tools and equipment to avoid exposure, such as robotics, as well as improvements of the working environment are also effective. Since these techniques constantly develop and improve, it is important to choose the best available at any time.

Work implementation

The work implementation phase refers to the actual performance of the work and to actions taken during this time which affect or facilitate the work. During work implementation, it is essential to ensure efficient control of radiological protection at the job location. There are several areas where work management can effectively contribute to lowering dose, time and cost. These include organisational aspects, such as the presence of radiological protection personnel, and specific procedures and technical aspects such as remote monitoring and access control systems. Efficient work process controls will help to assure that the objectives set during the work planning phase are met, that planned occupational radiological protection measures have been properly implemented and that any necessary corrective actions are identified and implemented. The reduction of unnecessary dose will be facilitated by providing workers with sufficient radiological, plant and job-specific information. Finally, the efficient collection of feedback information will assist in real-time work management and facilitate the preparation of future work.

Work assessment and feedback

The philosophy of work management can be seen as a continuous loop that consists of scheduling, planning, implementing, assessing, following up on lessons learnt and repeating the process for the next job to be undertaken, thus making the work cycle progressively optimised and in line with current technological developments. The job review and follow-up are among the most important parts of any task evolution. Normally, follow-up will lead directly into the implementation of the next operation under consideration. The lessons learnt, both good practices and areas for improvement, should be collected in a diligent manner, and exchanged not only with the work team but also with colleagues at the plant, industry and international levels. In a generic approach, two levels of information may be necessary to provide complete feedback on work implementation: the "internal" level, which consists of an analysis of in-plant performances, and the "external" level, which will provide national and/or international data favouring the exchange of new ideas and allowing the plant to assess its position with regard to other plants of the same type. Various information sources may be available for job dose assessment, such as the in-plant radiation exposure monitoring system database or corrective action programme, and corporate-wide, industry-wide and international databases of ALARA practices. Finally, work management implementation should be audited periodically to ensure that it is functioning properly.

Ensuring continuous improvement

While work management is an iterative process, it is also forward-looking, seeking continuous improvement to ensure and maintain a high level of radiological protection. Improvements therefore seek to incorporate, through information and experience exchange, lessons learnt and ongoing technological advances to inform not only future work activities, but also in the longer term, new design, new build and new operations to ensure that occupational radiological protection is optimised. In addition to experience exchange through programmes such as the ISOE, there is a range of technologies in various fields relevant to exposure reduction. These include technologies addressing source-term reduction, decontamination and mechanisation, automation and remote monitoring. Technologies for radiological protection and improvements in work efficiency have been broadly implemented in the nuclear industry. However, their ongoing development and further application should be considered in light of the radiological protection issues that will become important in the future, including exposure reduction in newly constructed or newly designed plants, large-scale modification works expected to be needed in association with ageing and lifetime extension of nuclear reactors, and reactor decommissioning.

This multi-disciplinary, practical experience in work management based on lessons drawn from many years of nuclear power plant operations, in addition to approaches that are still under development or that will be achieved in the future, are important elements in the optimisation of occupational radiological protection and for ensuring continuous improvement in the face of current and future challenges and opportunities.

Report availability

The ISOE report on *Work Management to Optimise Occupational Radiological Protection in the Nuclear Power Industry* can be downloaded, along with other ISOE reports, from the public section of the ISOE website, www.isoe-network.net (see ALARA Library/ISOE Reports). The report is currently available in English. Translations into other languages will also be posted on the ISOE website as these become available. ■

Cost estimation for decommissioning: a review of current practice

by P. O'Sullivan and C. Pescatore*

It is now common practice for decommissioning plans and associated cost estimates to be prepared for all nuclear installations. Specific requirements are generally set out in regulations that have their basis in national legislation. These estimates are important for ensuring that the necessary funds are being collected to cover the actual costs of decommissioning the facility. The long time horizon for both amassing and disbursing these funds is a particular concern for national authorities. It is thus important to maintain a realistic estimate of the liabilities involved and to confirm the adequacy of the provisions to discharge them over time.

Estimates of decommissioning costs have been performed and published by many organisations for many different purposes and applications. The results often vary because of differences in basic assumptions such as the choice of the decommissioning strategy (immediate vs. deferred), the availability of waste management pathways, the assumed end states of installations, the detailed definition of cost items, technical uncertainties, unforeseen events, the evolution of regulation and requirements. Many of these differences may be unavoidable since a reasonable degree of reliability and accuracy can only be achieved by developing decommissioning cost estimates on a case-by-case, site-specific basis. Moreover, even if considerable efforts are made to obtain reliable estimates, unforeseen events may cause estimates to go wrong. The issue of how to deal with uncertainties is therefore an important one, leading in turn to the need for risk management in terms of making adequate funding provisions.

In March 2008, a questionnaire was circulated among the organisations participating in the NEA Decommissioning and Cost Estimation Group (DCEG). Information was collected on legal requirements and the responsibilities of the main parties concerned with the preparation and oversight of cost estimates, the main cost elements and associated boundary conditions; cost estimation methodologies; and experience gained during the process. Twelve countries provided responses and participated in the analysis: Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, the Slovak Republic, Spain, Sweden, the United Kingdom and the United States. The final report[1] documenting the study is nearing publication. Its main findings are reported hereafter.

Status of cost estimation for decommissioning

The scope of decommissioning generally includes decontamination, removal/dismantling of disused plant and buildings, spent fuel storage or disposal, waste management, transport, and final disposal or long-term storage. However, some countries do not include the disposal of spent fuel, legacy wastes, waste disposal or its long-term storage in cost estimates for decommissioning.

Most countries have established requirements for cost estimation and reporting. Legal requirements include the preparation of a decommissioning plan and associated cost estimates, with periodic updates – usually every three to five years.

National requirements include administrative and substantive requirements. Administrative requirements are generally imposed by regulatory decrees or associated guidelines. Substantive requirements are generally related to explaining and justifying

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assumptions and boundary conditions in the cost estimates. These include boundary assumptions and conditions in cost estimates such as the year of the estimate, end point criteria, site release criteria, legacy waste disposal, spent fuel disposal, transition activities, characterisation, waste canisters, casks, transport, disposal options, disposal of high-level and low-level waste, scrap, salvage, remote handling techniques and project management. Some substantive requirements stipulate the use of overnight costs and means for handling escalation.

Stakeholders are generally allowed to review and to comment on cost estimates, but the owner is not usually bound to revise the estimate as a result of these comments.

A cost estimate for decommissioning is necessarily based on an assumed decommissioning strategy and on an assumed end state for the site. Given that the time frame for active decommissioning may often be several years (or even decades for plants licensed under early regimes) after the estimate has been made, these aspects represent significant uncertainties.

The nuclear safety regulator plays an important role in the approval of decommissioning strategies, cost estimating formats and funding. Most regulators do not prescribe a reporting format except in the United States where the Nuclear Regulatory Commission (NRC) has provided reference studies as guidance.

Some countries such as Canada and the United States require a cost-benefit analysis or the equivalent for assessing alternative decommissioning technologies and techniques.

Clearance and release levels have a major impact on costs. Whether the selected strategy is "greenfield" (usually seeking a return to pre-industrial site conditions) or "brownfield" (site re-use with limitations) strongly affects the total costs. These terms need to be defined in detail, however, as there is no universal interpretation.

Recently, and especially in the context of new nuclear power plant construction in several countries, existing nuclear sites have been gaining increasing strategic value. This may contribute to overall cost reduction by promoting earlier decommissioning of redundant facilities and from increased commercial value of the site.

Most countries, either through regulation or by owner preference, have adopted a formal organisation of the cost estimates. In general, detailed estimates are prepared, especially for plants that are already in operation. A work breakdown structure (WBS) format is used, based either on the Standardised List "Yellow Book" [2] **format or on an equivalent national format.**

Calculation methods vary by country. Some countries specify the type of cost estimate expected from operators, while others leave it to the operator to determine. The use of life cycle planning models is prevalent in Canada and the United Kingdom, with worst-case scenarios being used to bound the costs. Some countries such as the United States specify in detail how costs are to be reported, while others (such as France) specify the major cost categories, while allowing greater discretion on how estimates are structured.

Quality control is important for the validation of cost estimates. For example, the French Atomic Energy Commission (CEA) tracks cost estimates twice per year, and benchmarks actual experience against the cost estimate. In the United States, the NRC reviews the accuracy of cost estimates, requiring full documentation of how the estimated cost was developed.

Many countries have adopted the breakdown of activity-dependent and period-dependent costs to structure their estimates. Period-dependent costs could be broken down into defined time frames to reduce overall uncertainties. Several countries apply this notion by having different contingency factors for different phases of the project.

Contingencies are for unforeseen elements of cost within the defined project scope. Uncertainties are for unforeseeable elements of cost outside the defined project scope (such as currency exchange rate fluctuations, inflation beyond the norm of say 5% and regulatory changes). Some countries use a defined contingency: Belgium uses 15%, Canada uses a range based on estimate accuracy – a Grade A estimate 10%, Grade B 15-20%, Grade C 30% – the Slovak Republic uses 20-25%, Spain 15%, Sweden 6-20% and the US approximately 25%.

Ensuring robust cost estimates in the context of long-term uncertainties may be addressed either by the financing scheme or by including contingency factors in the cost estimate.

Risk analyses are being used more frequently in Sweden and the United Kingdom, based, for example, on Monte Carlo calculations – calculating a range of cost estimates and assigning simple distributions to each, and then multiple iterations calculating the distributions in size of the liabilities. Canada requires that cost estimates provide for escalation whereas, in Germany, this is specifically excluded. France follows a procedure for reducing uncertainties over time as the cost estimates improve in accuracy.

Decommissioning cost drivers

Experience of actual decommissioning projects leads to the following identification of the most significant cost elements and their ranking as cost drivers:

1. Scope definition and changes to the project plan.
2. Regulatory changes and increased requirements for additional information and detail.
3. End point state and disposal of waste.
4. Site characterisation of physical, radiological and hazardous materials inventory.
5. Waste storage and the availability of ultimate disposal facilities.
6. Disposal of spent nuclear fuel and on-site storage prior to a permanent repository.
7. Clean structure disposition and availability of the site for new developments.
8. Contingency application and use in estimates to account for uncertain events.
9. Availability of experienced personnel with knowledge of the relevant plant.
10. Assumed duration of the dismantling and clean-up activities.

Important considerations in ensuring accurate and stable cost estimates thus include avoiding changes in project scope (e.g. decommissioning strategy and end point), fixing regulatory standards during the planning phase of a decommissioning project to avoid delays during active decommissioning, and accurate characterisation of materials and soil.

Overall reflections

There is no single cost assessment methodology that applies equally at all stages of a decommissioning project. This means that different cost assessment methodologies may need to be used as the project advances. Such methodologies should be continuously updated using cost data from actual decommissioning projects, thus improving the cost assessment, providing better control of uncertainties and contingencies for each major cost category, and facilitating the preparation of an annualised schedule of expenditures for each facility.

In the future, risk management may benefit from an approach that uses a deterministic calculation (base case) that feeds into a probabilistic assessment of future costs. Such approaches may be used to gain a better understanding of potential cost and programme requirements.

Attention should also be given early on to socio-economic factors, including impacts caused by loss of employment, to help in building public support and acceptance of a decommissioning project. Early meetings with stakeholders may be used to gain agreement on project boundary conditions, strategy, release criteria and measurement protocols, and waste containers used.

In view of the very significant impacts that changes and increases in scope may have on cost estimates, it is important that these be identified and controlled immediately, and incorporated into the estimate so that the estimate may continue to provide a viable benchmarking resource.

Characterisation is acknowledged to be an important part of cost estimating accuracy, as it affects system and structure inventory, decontamination and waste disposal. Several countries look for cost reduction possibilities through waste minimisation processes.

Consideration should be given to developing upgraded decommissioning management systems to deal with latest developments, data quality, completeness and safety, while offering flexibility in data processing and cost calculations. Regular interaction between system developers and users is necessary to develop the inventory and maintain user friendliness.

Current good practices include the use of a standardised list of decommissioning activities, a strong quality-assurance programme, use of a dedicated decommissioning core group during the planning phase of decommissioning, and involvement of regulators and stakeholders in the drafting of decommissioning plans. ■

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Partnering with stakeholders in radioactive waste management

by C. Pescatore and A. Vari*

Site selection for radioactive waste management (RWM) facilities draws considerable attention from implementers, government bodies, local communities and the public at large. Facility siting processes have generally tended to be marred by conflicts, disagreements and delays. In response, efforts have been made to shift from a more traditional "decide, announce and defend" model to one of "engage, interact and co-operate". The essence of the new approach is co-operation or partnership between the implementer and the affected communities, involving dialogue between experts and citizens, mutual learning and public participation in the decision-making process. National ministries and authorities have also been called to and do play a more visible role. The intensity and degree of partnering can vary from country to country and in different phases of project development.

The FSC studies

In its first phase of work, the Forum on Stakeholder Confidence (FSC) synthesised countries' experience in its report entitled *Learning and Adapting to Societal Requirements for Radioactive Waste Management*.[1] Partnership approaches in Belgium, Canada and Finland were cited as examples of helping to achieve a balance between the requirements of fair representation and competent participation. Other advantages of the partnership approach were: helping to achieve a combination of a licensable site and a management concept with host community support, and helping to achieve a balance between compensation, local control and development opportunities. Those observations are still valid today. Since then, arrangements for some type of partnership approach have been incorporated into the RWM strategies of most NEA member countries. Such approaches to decision making, relying in particular on a concept of joint ownership of both the problem and the solution, are increasingly being implemented with success worldwide, including outside the radioactive waste management field.

A great variety of partnership arrangements exists based on the legal, institutional, political and cultural traditions within each country, the socio-economic characteristics of the affected communities and the specificities of the relevant national RWM programmes. The FSC is releasing a study[2] documenting how the approach to partnering has been or is being implemented in 13 countries, namely: Belgium, Canada, the Czech Republic, Finland, France, Hungary, Japan, Korea, Spain, Sweden, Switzerland, the United Kingdom and the United States. Of particular interest in this study is that the waste management programmes considered are at very different stages and, in each case, actual experience in implementation reflects participatory measures during the stage of designing the siting procedure or during the first siting steps.

Empowering local communities

The composition of the partnership organisms and the tasks to be carried out by them may also vary widely. Organisational formats (permanent or temporary working groups, panels, etc.) as well as results or outputs of collaboration with affected communities (such as design plans and recommendations to an elected or administrative authority) may vary from legally binding agreements to less formal arrangements. They all underline neverthless

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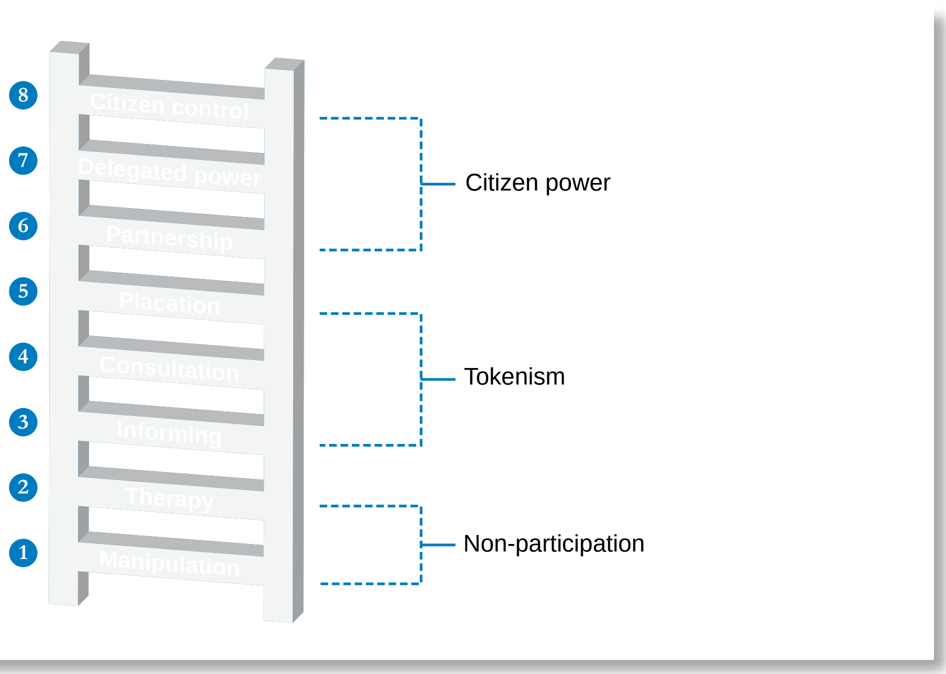
a determination to favour empowerment of communities in decisions that affect their future. Typically, partnership arrangements empower the local communities:

- to consult experts of their choice and to build up their own expertise in radioactive waste management;
- to provide authoritative recommendations to local, regional and national authorities;
- to influence the implementer's work in developing its waste management concept;
- to make meaningful suggestions for such elements as facility design features and infrastructure;
- to formulate plans for benefit packages that will profit their community in the short and long term on both social and economic grounds;
- to gather, assimilate and disseminate information on the implications of implementing a facility in their area;
- to stay abreast of research performed by the implementer, its consultants, the regulators and others;
- to monitor the performance of the various players and check their authenticity.

A necessary empowerment measure is that of community benefits. Several different and complementary types of benefits are found in partnership arrangements. Community engagement funding is an essential element of the partnership approach. It is necessary for citizens to hire (or release) their own secretarial or technical support or experts (scientists, lawyers, etc.) as well as to cover operating expenses. Engagement funding is designed to enable the affected communities to participate meaningfully in the collaboration process. Additional social and economic benefits take potential impacts of, and opportunities created by, RWM facilities into account. These ensure financial resources to support short-term development and/or long-term quality of life in the community. These benefits underscore the recognition that the community is volunteering an essential service to the country.

Two supporting measures typically confer additional margin of choice to the community. With volunteerism, the governing body of a community expresses the community's interest in participating in a process aimed at determining the suitability of a site for radioactive waste management on its territory. Such an expression of interest may be in response to an invitation by the waste management organisation or by the government, or it may be an unsolicited offer. With right of veto, the community is allowed to withdraw its offer from consideration within a certain period of time. In some countries the right of veto is ensured by law; in other countries it is granted based on an informal agreement amongst the parties involved. Due to the disposal concept, a limited number of suitable sites or to legal and political conditions, the possibilities for implementing volunteerism or right of veto may be limited in some countries.

Figure 1: Arnstein's eight-rung ladder of citizen participation



Ten years on: a leap from tokenism to real participation

For the purpose of analysing trends in stakeholder involvement over the past decade, it is instructive to compare the national contributions to the current study with those reported in a similar survey[3] of OECD countries that was carried out in the 1999-2002 time frame. The "ladder of citizen participation" proposed and elaborated by Arnstein[4] in 1969 provides a relevant framework to compare approaches or to study evolution in public involvement (Figure 1).

The bottom rungs of the ladder are identified as ❶ "Manipulation" and ❷ "Therapy". Both rungs describe levels of "non-participation", whereby the real objective is only to enable decision makers to "educate" or to "cure" the public.

Rungs ❸ and ❹ ("Informing" and "Consultation") increase the level of participation to that of "tokenism", whereby the public is allowed to listen and to have a voice. Under these conditions, however, citizens still lack the power to ensure that their views will be taken into consideration. Rung ❺, "Placation", is a higher level of "tokenism" in that citizens are allowed to give advice but there is no guarantee that their ideas will have an influence on the decisions.

Further up the ladder are levels of citizen involvement with increasing degrees of decision-making power. Citizens can enter into a "Partnership" (Rung ❻) that enables them to engage in negotiations with decision makers. At the highest levels of citizen participation, "Delegated power" (Rung ❼) and "Citizen control" (Rung ❽) refer to situations where citizens carry a majority stake in the decision or full executive power.

With reference to the Arnstein ladder, it can be observed that the focus on partnership revealed by answers to the 2008-09 survey is two rungs higher on the participation ladder than the focus on information and consultation revealed by the 1999-2002 survey, and represents an important leap from tokenism towards real participation. At the level of partnership, power is reapportioned through negotiation between citizens and decision makers. They agree to share planning and decision-making responsibilities through such structures as joint policy boards, planning committees and mechanisms for resolving impasses.

Overall observations

Important changes have taken place in citizen participation in radioactive waste management over the past decade. These changes can be summarised as follows:

- shift from information and consultation towards partnership, i.e. from token involvement to citizen influence and power;
- shift from a passive to an active role of local communities: from resigned acceptance to collaboration, volunteering and veto;
- development of a great variety of administrative formats for collaboration;
- recognition of the need for, and legitimacy of, community empowerment measures and socio-economic benefits;
- emergence of new ideals and bases for collaboration including mutual learning, adding values to the host community/region and sustainable development.

Involving local actors in the design of the facility and community benefits are likely to result in solutions that will add value to the host region. In all cases, social capital is augmented as local stakeholders develop new skills and increase their knowledge about the interests and ideals of their community. Implementers and other institutional players also improve themselves as responsive actors in the governance of radioactive waste and as responsible neighbours concerned with the well-being of the host region. ■

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MDEP: consolidation and expansion

by L. Burkhart*

The Multinational Design Evaluation Programme (MDEP) continues to progress in its efforts to facilitate the safe and efficient licensing and regulation of new nuclear reactors worldwide. The MDEP is an international initiative undertaken by the regulators of ten countries to co-operate on safety reviews of new reactor designs, to encourage harmonisation of regulatory requirements and practices, and to find ways to do so. The International Atomic Energy Agency (IAEA) also participates in the MDEP efforts. Since the last *NEA News* update, the structure of the MDEP has evolved in order to better meet the challenges of licensing new reactors, but its purpose remains the same: to make regulatory design reviews more safety-focused and to leverage regulatory resources to ensure the safe operation of tomorrow's operating reactors.

As a backdrop to the MDEP is a world in which nuclear power plant design and construction is receiving both new and increasing interest. Construction has been ongoing in many of the MDEP countries for years such as in China, Japan, Korea and Russia. Two new European pressurised reactors (EPRs) have been under construction for some time in Finland and France. And governments are keenly engaged in new reactor design reviews in Canada, the United Kingdom, the United States and the other MDEP countries. The reality of the situation makes the work of the MDEP that much more vital to focusing the limited resources of government regulators on the most safety-significant issues. Leveraging each other's resources remains one of the advantages of working closely together on the MDEP.

The work of the MDEP has been consolidated from what was a three-stage programme a few years ago to a comprehensive programme that is working on the immediate design reviews of reactors that are being constructed and licensed in several MDEP countries, the convergence of mechanical and electrical component codes and standards, and the coordination of vendor inspections. Governed by the ten-member Policy Group consisting of the top regulatory officials from MDEP countries, the work is implemented by the MDEP Steering Technical Committee which, in turn, provides guidance and direction to the five official working groups. These working groups are the two design-specific working groups – one each on AREVA's EPR design and Westinghouse's AP1000 design – and the three issue-specific working groups addressing mechanical component codes and standards, digital instrumentation and control issues, and vendor inspection co-operation efforts. The former working groups concentrate on sharing information among MDEP regulators on the various safety review efforts of the two designs, and the latter three are concentrating on addressing potential convergence and harmonisation in regulatory requirements and practices.

The Policy Group (PG), which is chaired by Mr. André-Claude Lacoste, Chairman of the French Nuclear Safety Authority (ASN), meets annually to discuss the results and future direction of the MDEP, making adjustments and providing policy direction to ensure that the programme is meeting its goals. At its March 2009 annual meeting, the PG approved converting the MDEP from a two-year project to a multi-year programme that should provide important interim results on new reactor issues. Another key effort of the PG has been to make more information available to other stakeholders, especially to non-MDEP regulators. A milestone event in carrying out this directive was the successful conduct of the MDEP Conference on New Reactor Design Activities, which was coordinated by the NEA MDEP Technical Secretariat staff and held at the OECD Conference Centre on 10-11 September 2009. Over 170 people attended from 23 countries and 11 international organisations.

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The Steering Technical Committee (STC), which is chaired by Mr. Gary Holahan from the US Nuclear Regulatory Commission (NRC) Office of New Reactors and which is comprised of members from all MDEP-country regulatory authorities having responsibility for licensing new reactors, provides direction and guidance to the working groups and consults the PG on important policy issues. The STC meets three times a year, usually in Paris, to review the status of each working group and to discuss evolving issues that may be addressed by the MDEP. As stated in the MDEP Terms of Reference, one of the key goals of the MDEP is to facilitate the licensing of Generation IV reactors when the time comes. The PG and the STC keep this in mind to ensure the long-term focus of MDEP efforts while balancing the need to obtain immediate co-operative results in the design-specific working groups.

The design-specific working groups include the most mature and the youngest of the MDEP working groups. The EPR Working Group has been in existence, in one form or another, for at least three years. Faced with the construction and/or licensing of the EPR in Canada, China, Finland (Chair), France (Co-Chair), the United Kingdom and the United States, these regulators are working together to discuss the various designs and to concentrate on coordinating the safety reviews and their results. The EPR Working Group meets twice a year and also includes co-operative efforts on specific areas such as digital instrumentation and control, probabilistic safety assessment, severe accidents, accidents and transients, radiological protection, human factors engineering and fire protection. The AP1000 Working Group involves the regulators facing reviews of that design such as Canada, China (Co-Chair), the United Kingdom and the United States (Chair). The AP1000 is under construction in China and under intense design reviews in these four countries. The AP1000 Working Group just completed its second meeting in September 2009 after its initial meeting in China in February 2009. Specific areas of co-operation include reviews of the large squib valves that are utilised to initiate the passive emergency core cooling systems, civil engineering and the structural review of the shield building, and the control rod drive mechanisms.

The issue-specific working groups are tasked with studying the similarities and differences in regulatory requirements and practices and trying to understand how complying with requirements in one country may apply or not apply to meeting requirements in another. Finding ways to eventually harmonise these requirements is a clear goal of the MDEP. For instance, in the Codes and Standards Working Group (CSWG), the MDEP regulators are working with the various mechanical codes standards development organisations (SDOs) to study how the codes differ and why among the MDEP countries. This work is nearly complete for comparing these standards between France, Japan, Korea and the United States, and will be started soon for Canada and Russia. Once the difference and similarities are identified, potential paths to take to encourage convergence will be discussed and pursued.

The same sorts of efforts are ongoing as part of the Digital Instrumentation and Control Working Group (DICWG). This group is consulting with national and international electric standards development organisations such as the Institute of Electrical and Electronic Engineers (IEEE) and the International Electrotechnical Commission (IEC) to look for possible ways to achieve convergence.

The Vendor Inspection Co-operation Working Group (VICWG) is coordinating inspections among interested MDEP countries. In these efforts, one regulator conducts a vendor inspection and invites other MDEP regulators to witness the activities in order to facilitate familiarisation with each other's inspection procedures, conduct and documentation. Already about eight of these witnessed inspections have been completed and many more are planned. This work will lead to a better understanding about how one country can use the results of another country's inspection. The scope of these inspections is expected to expand from only pressure vessels to other components such as ASME Class 1 pipes, pumps and valves.

The results from these working groups' activities are communicated back to the STC and the PG, and an MDEP annual report is issued and made available to the public on the NEA's MDEP web pages (www.nea.fr/mdep). The Policy Group is leading the effort to make more information available to other stakeholders, especially to non-MDEP regulators. As mentioned previously, a key step in making more MDEP information available to these stakeholders was accomplished at the September 2009 Conference on New Reactor Design Activities, and a follow-on conference was proposed by the PG Chair in approximately two years. With the success of this conference and the PG approval to extend the MDEP to a long-term programme, we can be confident that the MDEP will continue to make a difference in new reactor regulation from now until the time that Generation IV reactors are under review. ■

A legislative framework for the safety of nuclear installations in the European Union

by S. Kuş and S. Emmerechts*

For the first time since the inception of the European Community in 1957 and after two previously unsuccessful attempts, on 25 June 2009 the Council of the European Union adopted European-wide, binding requirements on nuclear safety.[1]

The goal of the "Council Directive establishing a Community framework for the nuclear safety of nuclear installations" ("the Directive") is to maintain and to promote the continuous improvement of nuclear safety and to ensure that a high level of nuclear safety is provided by EU member states to protect workers and the general public against the dangers arising from nuclear installations. The Directive is based on the IAEA Safety Fundamentals and the Convention on Nuclear Safety.

The 27 member states of the Community are required to bring into force the laws, regulations and administrative provisions necessary to comply with the Directive by 22 July 2011.

Background

In 2003, the European Commission proposed a so-called "nuclear package" containing EU-wide, harmonised rules in the fields of nuclear safety and the safe management of spent fuel and radioactive waste.[2] The proposal was very ambitious, including verifications of national safety authorities by the EU Commission, the development of EU-specific safety standards, strict rules on financial resources for the decommissioning of nuclear installations and on the independence of national safety authorities.

One of the main arguments of the Commission to justify its initiative was that greater harmonisation of safety requirements for nuclear installations in the EU is a prerequisite for the future development of nuclear energy, especially in view of the forthcoming enlargement of the Community.[3] The Commission also argued[4] that nuclear energy must remain an option in the energy mix of the future in order to achieve greenhouse gas emission reductions driven by the targets in the Kyoto Protocol.[5]

The initiative encountered strong opposition and criticism by several member states which led the Commission to submit in September 2004 new and revised legislative proposals.[6] However, the Council remained strictly divided between member states supporting and those strongly opposing the Commission's initiative. The main arguments of the opponents were that the European Community lacks legal competence in the field of nuclear safety, that its legislative proposals were not substantive enough and that they did not provide an additional value *vis-à-vis* existing international co-operation at the level of the International Atomic Energy Agency (IAEA), the OECD Nuclear Energy Agency (NEA) and other groups such as the Western European Nuclear Regulators Association (WENRA).

In that context, instead of discussing the proposals further the Council commenced an alternative process. In 2004, it created an ad hoc Council working party to engage in a wide-ranging consultation process with experts from member states facilitating the choice of effective legal instrument(s) for achieving nuclear safety and the safe management of spent fuel and radioactive waste. Despite extensive discussions

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and reports during 2005 and 2006, there was still no consensus on the adoption of the legislative proposals.

In 2007, the Council paved the way for the creation of the High Level Group on Nuclear Safety and Waste Management[7] [later renamed the European Nuclear Safety Regulators Group (ENSREG)], an independent, authoritative expert body composed of senior officials from national regulatory or nuclear safety authorities from all 27 member states to advise and assist the Commission in progressively developing common understanding and eventually additional European rules on the safety of nuclear installations and the safety of the management of spent fuel and radioactive waste. The discussions and the compromises reached within this High Level Group were instrumental in adopting the Directive on 25 June 2009.[8]

Main provisions

The Directive applies to a range of nuclear installations that is wider than the one adopted in the Convention on Nuclear Safety.[9] The Directive applies to any civilian nuclear installation, defined as:

a) an enrichment plant, nuclear fuel fabrication plant, nuclear power plant, reprocessing plant, research reactor facility, spent fuel storage facility; and

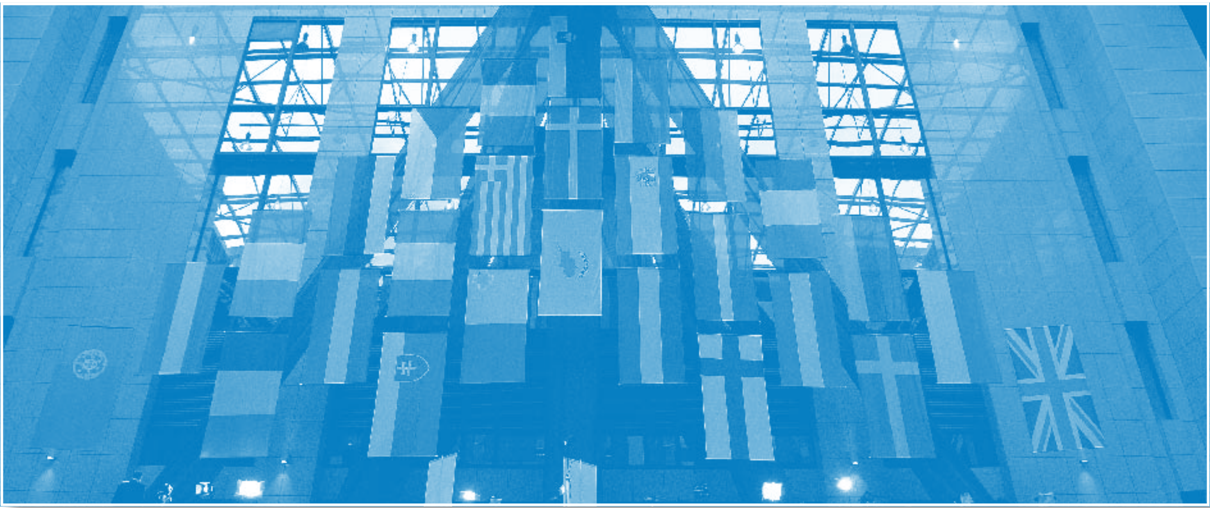
b) storage facilities for radioactive waste that are on the same site and are directly related to nuclear installations listed under point a).

The scope of the Directive ranges further in time than the Convention on Nuclear Safety, also covering the decommissioning phase of a nuclear installation.[10] Another interesting difference is that while the Convention on Nuclear Safety is silent on the definition of nuclear safety, the Directive attempts such a definition in that it states that "nuclear safety" means "the achievement of proper operating conditions, prevention of accidents and mitigation of accident consequences, resulting in protection of workers and the general public from dangers arising from ionizing radiations from nuclear installations".[11]

Member states shall establish and maintain a national legislative, regulatory and organisational framework with responsibilities for the adoption of national nuclear safety requirements; the provision of a system of licensing and prohibition of operation of nuclear installations without a licence; the provision of a system of nuclear safety supervision; and enforcement actions, including suspension of operation and modification or revocation of a licence.[12]

The Directive further includes a well-known requirement which many international instruments in the field of nuclear law address, namely that member states shall establish and maintain a competent regulatory authority, "functionally separate from any other body or organisation concerned with the promotion, or utilisation of nuclear energy, including electricity production, in order to ensure effective independence from undue influence in its regulatory decision making".[13]

The obligation to give the competent regulatory authority the legal powers and human and financial resources necessary to fulfil its obligations in connection with the national framework is also customary under international nuclear law. However, what is rather unparalleled is to impose a similar obligation on license holders.[14] At the level of the European Union and its supranational character, both obligations can imply greater impacts than at any other intergovernmental level. Other provisions address the prime responsibility of the licence holder, regular safety assessments and transparency.



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On 25 June 2009, the Council of the European Union adopted European-wide, binding requirements on nuclear safety.

With respect to procedural provisions, the Directive obliges member states to report to the Commission on the implementation of the Directive for the first time by 22 July 2014, and every three years thereafter, taking advantage of the review and reporting cycles under the Convention on Nuclear Safety. On the basis of these reports, the Commission shall submit a report to the Council and the European Parliament.

Enforcement

The Directive is without doubt a milestone in international and regional law making in the field of nuclear law, not so much because of its content but because of the supranational nature of European law and the powers of EU institutions.

Member states have long resisted the Directive because of the powers which it delegates to the European Commission, and more importantly, to the European Court of Justice. The Commission, as the guardian of the treaties and the measures taken by the institutions, ensures that EU legislation is applied correctly by the member states. It can start infringement procedures if not satisfied with a member state's implementation of the Directive and refer the matter to the European Court of Justice. The court will therefore have the final decision on, for example, the implementation of nuclear safety requirements, the independence of the regulatory body and the adequacy of human and financial resources. As a last resort, the court may impose a lump sum or penalty payment on the member state which fails to fulfil an obligation.[15] In this way, the Directive may generate a legal effect that is far more important than the Convention on Nuclear Safety, which is considered to be an "incentive" convention without strict enforcement possibilities.

Outlook

Even though the Directive faces criticism with respect to its "diluted" provisions, it is in theory forceful from the implementation and enforcement perspectives. It remains to be seen how rigorously the Commission will monitor the way in which the Directive is implemented, and especially its vaguer provisions which are also amongst the most controversial issues in the field of international nuclear law, e.g. the independence of the regulatory body from undue influence.

As the Directive states in its preamble, the member states of the European Union have already implemented measures enabling them to achieve a high level of nuclear safety within the Community. Both Euratom and its member states have co-operated at the international level, subjected their national regulators and regulations to international peer reviews and helped to improve nuclear safety worldwide. The Directive is a major step for achieving a common legal framework and a strong nuclear safety culture in Europe which could become a model for other regions to translate internationally accepted safety standards into a legally binding framework. ■

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5. Amendment to the United Nations Framework Convention on Climate Change, which was opened for signature on 11 December 1997 and came into force on 16 February 2005.
6. European Commission document COM(2004) 526 final. A Directive is a legislative instrument of the European Union which requires EU member states to achieve a particular result without dictating the means of achieving that result.
7. Commission Decision 2007/530/Euratom of 17 July 2007.
8. The Commission will continue its efforts to enact a legislative instrument for the management of spent fuel and radioactive waste. Paragraph 12 of the Directive's preamble states: "While this Directive concerns principally the nuclear safety of nuclear installations, it is also important to ensure the safe management of spent fuel and radioactive waste, including at storage and disposal facilities."
9. The scope of the Convention on Nuclear Safety is basically limited to operational land-based civil nuclear power plants and storage/treatment facilities on the same site and directly related to their operation.
10. The Convention on Nuclear Safety is generally understood to apply until a decommissioning programme has been agreed to by the regulator.
11. Article 3(2) of the Directive.
12. Article 4 of the Directive.
13. Article 5(1)(2) of the Directive.
14. Articles 5(3) and 6(5) of the Directive.
15. Article 143 of the Euratom Treaty.

News briefs

NEA activities on medical isotope supply issues

by C. Westmacott and R. Vance*

Medical radioisotopes play a vital role in modern medical practices. One of their principal uses is for nuclear diagnostic imaging techniques. These techniques are powerful and non-invasive, allowing the identification of common diseases such as heart conditions and cancer at an early stage, tracking disease progression and providing predictive information about likely success of a therapy. Such techniques enable precise and accurate management of the disease and may significantly assist in the medical decision-making process, for example removing the need for surgical intervention to obtain diagnostic information. Every year, 46 million people are estimated to benefit globally from such nuclear medicine testing.

However, over the last few years there have been a number of supply shortages of Molybdenum-99 (Mo-99) and its decay product, Technetium-99m (Tc 99m), the most widely used medical radioisotope. These isotopes decay within a matter of days; therefore they must be produced continually in order to meet demand. Most recently, the unexpected extended shutdown of Canada's NRU research reactor – which produces approximately 35 percent of world Mo-99 supply – has compounded existing concerns regarding the supply reliability of these medical radioisotopes. Currently, five reactors between 42 and 52 years old produce over 95 percent of the world's supply of Mo-99 and face challenges in maintaining a continuous supply to the health community. As outlined above, disruptions in this supply chain have affected the availability of vital medical testing for millions of patients around the world.

On 29-30 January 2009, the NEA hosted a workshop on Security of Supply of Medical Radioisotopes at the request of the Government of Canada. The workshop assembled an international group of experts to identify challenges faced in providing a reliable supply of Mo-99 and Tc-99m and measures that should be taken to ensure such reliability.

Workshop participants discussed a wide variety of challenges: the management of existing capacities and maximisation of these capacities in times of shortages; the economic validity of the current model of producing isotopes; flexibility and efficiency of the supply chain; regulatory requirements; and demand-side management. They identified the need to develop, deepen and share, as appropriate, contingency plans for future supply disruptions. They also focused on the longer term and on the need to engage health authorities to reduce uncertainties regarding long-term demand and the means by which to encourage more investment in production and greater spare capacity in the system.

At the workshop, there was unanimous support for the establishment of a working group to carry forward the conclusions of the workshop and to identify the practical measures that should be taken. This working group, the High-level Group on the Security of Supply of Medical Radioisotopes (HLG-MR), was established by the NEA following endorsement by the Steering Committee for Nuclear Energy, and is comprised of 20 experts from 11 countries, the European Commission and the International Atomic Energy Agency. The group will oversee and assist, where necessary, efforts of the international community to address the challenges of medical isotope supply reliability.

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Photos courtesy of AECL, Canada

The NRU research reactor where approximately 35% of world Mo-99 supply is produced.

The HLG-MR has begun work towards increasing the reliability of supply, agreeing to focus first on ensuring that supply and demand information is available and shared amongst all stakeholders and that the available supply is utilised as efficiently as possible. It will then start assessing options to increase short-, medium- and long-term production. As part of the examination of long-term production options, due consideration will be given to encouraging the development of infrastructure using low-enriched uranium.

A key issue raised during HLG-MR discussions and through other initiatives is the possibility of a market failure in the upstream supply chain, whereby it is not economically sustainable for current reactors to produce Mo-99, nor is there sufficient incentive based on the current economic structure to develop additional reactors in order to produce additional Mo-99. As a result, the NEA is undertaking an economic study of the upstream Mo-99 and Tc-99m supply chain. This study is intended to develop a solid factual basis to determine whether there has been a market failure in the supply chain. If so, the study will provide recommendations on how to address this failure in order to create an environment that encourages sufficient investment in medical radioisotope production and related infrastructure. Recommendations may also focus on the appropriate balance between benefits and costs of Mo-99 provision and a better allocation of responsibilities for costs between public and private stakeholders.

The NEA and its HLG-MR recognise that there are a number of other fora also addressing the reliability of medical isotope supply, and care is being taken to ensure that efforts are not duplicated. The NEA's goal in getting involved in this issue is to bring added value to the ongoing work and to support member countries. Bringing the international community together to discuss, share and learn, and applying NEA expertise on nuclear issues and economic studies, represent important contributions to the current global effort. ■

Nuclear power in NEA member countries

Situation as of 31 December 2008

At the end of 2008, the total nuclear generating capacity of the 345 reactors connected to the grid in NEA member countries was 309.3 gigawatts (GWe). Another 15 reactors totalling 15.9 GWe were under construction and 23 reactors totalling 28.4 GWe were firmly committed. These and other statistics are provided in the latest edition of *Nuclear Energy Data*, as well as short country reports on important trends and issues.

Nuclear generating capacity (net GWe) **and percentage of total electricity generating capacity** (a)

Country	2008		2010		2020		2030	
	Nuclear	%	Nuclear	%	Nuclear	%	Nuclear	%
Belgium (c)	5.8 (b)	34.9	5.8 - 5.9	35.2 - 33.7	4.0 - 5.9	20.0 - 23.6	N/A	N/A
Canada	12.7	10.9	11.4 - 14.3	9.6 - N/A	11.4 - 15.3	8.7 - N/A	N/A	N/A
Czech Republic	3.6	20.3	3.6 - 3.8	21.2 - 21.1	3.8 - 4.9	21.7 - 26.9	6.0 - 6.2	30.8 - 30.2
Finland	2.7	21.4	2.7	19.3	4.3	25.3 - 24.0	3.8	22.0 - 20.4
France	63.3	53.8	63.1	52.1 - 51.7	64.6 - 66.4	N/A	N/A	N/A
Germany	20.4 (b)	13.8	20.4	13.6 - 13.2	3.5	2.3 - 2.1	0.0	0.0 - 0.0
Hungary	1.9 (b)	23.8	1.9	23.4 - 21.3	1.9	21.5 - 20.1	1.9	21.0 - 18.0
Japan (e, f)	47.5 *	19.9	N/A	N/A	N/A	N/A	N/A	N/A
Korea	17.7	24.8	18.7	24.6	31.5	31.5	N/A	N/A
Mexico	1.4	2.4	1.4 - 1.6	N/A - 2.6	N/A - 1.6	N/A	N/A - 1.6	N/A
Netherlands	0.5	2.6	0.5	2.3 - 2.2	0.5	N/A	0.5	N/A
Slovak Republic	1.7	24.2	1.6 - 1.8	24.2 - 22.2	2.5 - 3.9	31.3 - 36.3	3.4 - 4.1	33.0 - 35.3
Spain	7.5	8.3	7.6	8.5	7.6	6.0	N/A	N/A
Sweden	9.0 *	26.3	10.1 - N/A	N/A	10.1 - N/A	N/A	10.1 - N/A	N/A
Switzerland	3.2	18.7	3.2 - N/A	18.7 - N/A	3.2 - N/A	17.7 - N/A	3.9 - N/A	20.7 - N/A
United Kingdom (d)	10.1	12.6	10.5	11.9 - 11.8	4.4 - 5.8	5.0 - 6.5	N/A	N/A
United States	100.3 (b)	9.9	101.2	9.7	105.1 - 113.8	9.7 - 10.5	74.3 - 132.2	6.1 - 10.8
Total/average	309.3	12.9	-	-	-	-	-	-

(a) Including electricity generated by the user (autoproduction) unless stated otherwise.
(b) Provisional data.
(c) By law, Belgium's nuclear power plants must be retired from service after 40 years of operation, except in the case of a *force majeure* called by Belgian authorities. The high figures take into account this *force majeure*.
(d) Excluding electricity generated by the user (autoproduction).
(e) For fiscal year.
(f) Gross data converted to net by the Secretariat.
* Secretariat estimate.
N/A Not available.

Status of nuclear power plants and corresponding capacity (net GWe)

Country	Connected to the grid		Under construction		Firmly committed*		Planned shutdown**	
	Units	Capacity	Units	Capacity	Units	Capacity	Units	Capacity
Belgium	7	5.8	-	-	-	-	-	-
Canada	20 (a)	12.7	-	-	-	-	-	-
Czech Republic	6	3.6	-	-	-	-	-	-
Finland	4	2.7	1	1.6	-	-	-	-
France	59	63.3	1	1.6	1	1.6	1	0.1
Germany	17	20.4	-	-	-	-	6	6.1
Hungary	4	1.9	-	-	-	-	-	-
Japan (e)	55	47.5	4 (f)	3.8	11	13.0	1	0.4
Korea	20	17.7	6 (g)	6.8	2	2.8	-	-
Mexico	2	1.4	-	-	-	-	-	-
Netherlands	1	0.5	-	-	-	-	-	-
Slovak Republic	4	1.7 (c)	2 (d)	0.9	-	-	-	-
Spain	8	7.5	-	-	-	-	-	-
Sweden	10	9.0	-	-	-	-	-	-
Switzerland	5	3.2	-	-	-	-	-	-
United Kingdom	19	10.1	-	-	-	-	4	1.4
United States	104	100.3	1 (b)	1.2	9	11.0	-	-
Total	345	309.3	15	15.9	23	28.4	12	8.0

(a) Includes three units currently under refurbishment (Point Lepreau and Bruce A units 1 and 2).
(b) Watts Bar 2 construction resumed.
(c) Bohunice 2 retired from service on 31 December 2008.
(d) Mochovce 3 and 4 construction resumed.
(e) Gross data converted to net by the Secretariat.
(f) Includes one plant with government approval but no concrete poured and ongoing work to restart Monju FBR.
(g) Includes one plant with government approval but no concrete poured.
* Plants for which sites have been secured and main contracts placed.
** Plants expected to be retired from service by the end of 2013.

New publications

Economic and technical aspects of the nuclear fuel cycle

Nuclear Energy Data 2009/Données sur l'énergie nucléaire 2009

ISBN 978-92-64-04772-3. 120 pages. Price: € 35, US$ 47, £ 29, ¥ 4 300.

This new edition of *Nuclear Energy Data*, the OECD Nuclear Energy Agency's annual compilation of essential statistics on nuclear energy in OECD countries, provides information on plans for new nuclear construction, nuclear fuel cycle developments and projections of installed nuclear capacity to 2035 in OECD member countries. This comprehensive overview of the current situation and expected trends in various sectors of the nuclear fuel cycle provides authoritative information for policy makers, experts and academics working in the nuclear energy field.

The Financing of Nuclear Power Plants

ISBN 978-92-64-07921-2. 74 pages. Price: € 30, US$ 40, £ 25, ¥ 3 700.

Many countries have recognised that greater use of nuclear power could play a valuable role in reducing carbon dioxide emissions. However, given the high capital cost and complexity of nuclear power plants, financing their construction often remains a challenge. This is especially true where such financing is left to the private sector in the context of competitive electricity markets. This study examines the financial risks involved in investing in a new nuclear power plant, how these can be mitigated, and how projects can be structured so that residual risks are taken by those best able to manage them. Given that expansion of nuclear power programmes will require strong and sustained government support, the study highlights the role of governments in facilitating and encouraging investment in new nuclear generating capacity.

Nuclear safety and regulation

Nuclear Fuel Behaviour in Loss-of-coolant Accident (LOCA) Conditions

State-of-the-art Report

ISBN 978-92-64-99091-3. 376 pages. Free: paper or web.

Considerable experimental and analytical work has been performed in recent years which has led to a broader and deeper understanding of phenomena related to loss-of-coolant accidents (LOCAs). Further, new cladding alloys have been produced, which might behave differently than the previously used Zircaloy-4, both under normal operating conditions and during transients. Compared with 20 years ago, fuel burn-up has been significantly increased. These and other factors have led the NEA Committee on the Safety of Nuclear Installations (CSNI) and its Working Group on Fuel Safety to produce this state-of-the-art report. The report should be of particular interest to nuclear safety regulators, nuclear power plant operators and nuclear fuel researchers.

Radiological protection

法令にみる環境放射線防護

Japanese version of *Environmental Radiological Protection in the Law*

ISBN 978-92-64-99098-2. 62 pages. Free: paper or web.

Evolution of the System of Radiological Protection

Discussion of New ICRP Recommendations, 4th Asian Regional Conference, Tokyo, Japan, 13-14 December 2007

ISBN 978-92-64-99088-3. 48 pages. Free: paper or web.

The evolution of the system of radiological protection is of great interest to governments and regulatory authorities, in particular in Asia. In this context, the Japanese government hosted a series of NEA conferences on this subject. The 4th Asian Regional Conference, held in Tokyo in December 2007, included key discussions of Japanese, Korean, Chinese and Russian views on the new International Commission on Radiological Protection (ICRP) recommendations, and on their interpretation in the international Basic Safety Standards and national regulations. This report summarises the most significant aspects of these discussions, providing keen insight into governmental and regulatory approaches to radiological protection in Asia.

放射線防護における科学的問題と新たな課題

Japanese version of *Scientific Issues and Emerging Challenges for Radiological Protection*
Report of the Expert Group on the Implications of Radiological Protection Science

ISBN 978-92-64-99099-9. 120 pages. Free: paper or web.

Work Management to Optimise Occupational Radiological Protection at Nuclear Power Plants

ISBN 978-92-64-99089-0. 128 pages. Free: paper or web.

Since 1992, the Information System on Occupational Exposure (ISOE) has provided a forum for radiological protection professionals from nuclear power utilities and national regulatory authorities worldwide to discuss, promote and co-ordinate international co-operative undertakings for the radiological protection of workers at nuclear power plants. The ISOE objective is to improve occupational exposure management at nuclear power plants by exchanging relevant information, data and experience on methods to optimise occupational radiological protection. This report on work management provides practical guidance on the application of work management principles as a contribution to the optimisation of occupational radiological protection. It recognises that while work management is no longer a new concept, continued efforts are needed to ensure that good performance, outcomes and trends are maintained in the face of current and future challenges. The focus of this report is therefore on presenting the key aspects of work management that should be considered by management and workers to save time, doses and money, supported by updated practical examples from within the ISOE community. ISOE is jointly sponsored by the OECD Nuclear Energy Agency and the International Atomic Energy Agency (IAEA). ISOE Network: www.isoe-network.net.

Radioactive waste management

A Common Objective, a Variety of Paths

Synthesis and Main Lessons: Third International Conference on Geological Repositories, Berne, Switzerland, 15-17 October 2007

ISBN 978-92-64-99100-2. 40 pages. Free: paper or web.

High-level political, governmental and regulatory decision makers, as well as representatives of economic and social groups and implementing organisations met in Berne, Switzerland to present and to reflect on their collective experience towards meeting the challenge of implementing national disposal projects for placing radioactive waste in deep geological formations. This summary highlights the main lessons to be learnt and final recommendations to assist future developments in national radioactive waste management programmes seeking to meet both technical and social imperatives of modern society.

Third International Conference on Geological Repositories, Berne, Switzerland, 15-17 October 2007

ISBN 978-92-64-99101-9. Web only.

These proceedings include the papers presented at the conference as well as a summary which highlights the main lessons to be learnt and final recommendations to assist future developments in national radioactive waste management programmes seeking to meet both technical and social imperatives of modern society.

Approaches and Challenges for the Use of Geological Information in the Safety Case for Deep Disposal of Radioactive Waste

Third AMIGO Workshop Proceedings, Nancy, France, 15-17 April 2008

ISBN 978-92-64-99090-6. 76 pages. Free: paper (including a CD-ROM) or web.

A cornerstone of national decision making and societal acceptance of deep geological disposal of radioactive waste is confidence that such repositories can protect humans and the environment both now and in the future. The "safety case" is the synthesis of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe after closure and beyond the time when active control of the facility is ensured. For deep geological disposal, studies of the geosphere form a principal component of the safety case. Geoscientific information is unique in that it can offer evidence and lines of reasoning that span geological timescales (millennia and even longer). The NEA Approaches and Methods for Integrating Geological Information in the Safety Case (AMIGO) project addresses the collection and integration of geoscientific evidence, analyses and arguments that contribute to an understanding of long-term safety. The third and final AMIGO workshop on "Approaches and Challenges for the Use of Geological Information in the Safety Case" underscored that geoscientific information plays a fundamental role in safety assessments. It is also increasingly used in the wider context of the safety case to provide evidence and arguments for the intrinsically favourable properties of a site, including its long-term stability. No single geoscientific argument "proves" safety, but rather each supports some key element of the safety case and provides enhanced confidence in the safety case. The workshop also considered the links and feedback among the safety case; design, engineering and construction issues; and geoscientific investigations.

Decommissioning of Nuclear Facilities (brochure)

It can and has been done

8 pages. Free: paper or web.

Considerable international experience gained over the last 20 years demonstrates that nuclear facilities can be safely dismantled and decommissioned once a decision is made to cease operations and permanently shut them down. This brochure looks at decommissioning across a spectrum of nuclear facilities and shows worldwide examples of sucessful projects.

International Experiences in Safety Cases for Geological Repositories (INTESC)

Outcomes of the INTESC Project

ISBN 978-92-64-99103-3. 76 pages. Free: paper (including a CD-ROM) or web.

A "safety case" is the synthesis of evidence, analyses and arguments that quantify and substantiate a claim that a geological repository for radioactive waste will be safe after closure and beyond the time when active control of the facility can be ensured. The NEA project on International Experiences in Safety Cases for Geological Repositories (INTESC) analysed existing safety cases, and their elements, to provide an overview of progress during the last decade, to identify key concepts and to give insight into regulatory expectations on the contents and review of safety cases. This report documents the outcomes of the INTESC project. It takes account of the responses to a detailed survey of NEA member countries as well as the results of a technical workshop. The project has shown that the purpose and concept of a safety case are generally understood, accepted and adopted by radioactive waste management programmes worldwide. Programmes are preparing safety cases in line with most of the elements suggested by the NEA, although there are some differences in interpretation and presentation. Some important trends are emerging, such as the use of safety functions and the role of a geosynthesis. Further development of some aspects and tools, such as quality assurance programmes and requirements management systems, can be expected as safety cases are further refined to support programmes moving towards implementation of geological disposal.

Nuclear law

Nuclear Law Bulletin No. 83 (June 2009)

ISSN 0304-341X. Yearly subscription (two issues): € 114, US$ 150, £ 79, ¥ 16 500.

Considered to be the standard reference work for both professionals and academics in the field of nuclear law, the *Nuclear Law Bulletin* is a unique international publication providing its suscribers with up-to-date information on all major developments falling within the domain of nuclear law. Published twice a year in both English and French, it covers legislative developments in almost 60 countries around the world as well as reporting on relevant jurisprudence and administrative decisions, international agreements and regulatory activities of international organisations. Feature articles in this issue address "The Review Conference Mechanism in Nuclear Law: Issues and Opportunities", "National Implementation and Enforcement of Nuclear-Weapon-Free Zone Treaties" and "The Decommissioning of Asse II – Burden of the Past in the Federal Republic of Germany".

Nuclear science and the Data Bank

International Evaluation Co-operation

Evaluated Data Library for the Bulk of Fission Products (Volume 23)

ISBN 978-92-64-99092-0. 44 pages. Free: paper or web.

This publication reports the conclusions from the work undertaken by Subgroup 23 of the NEA Working Party on International Nuclear Data Evaluation Co-operation (WPEC), whose mission was to produce an international library of neutron cross-section evaluations for the most important fission products. These fission products are important in the operation of nuclear reactors because some of them contribute delayed neutrons that are useful for reactor control, whereas others have a very high neutron capture cross-section, thus inhibiting the nuclear reaction. The build-up of the fission product poisons determines the maximum duration a given fuel element can be kept in a reactor.

Inter-code Comparison Exercise for Criticality Excursion Analysis

Benchmarks Phase I: Pulse Mode Experiments with Uranyl Nitrate Solution Using the TRACY and SILENE Experimental Facilities

ISBN 978-92-64-99073-9. 172 pages. Free: paper or web.

The NEA Working Party on Nuclear Criticality Safety established an Expert Group on Criticality Excursion Analysis in 2001 to explore the performance of various transient codes to evaluate criticality accidents in a fissile solution. Inter-code comparison exercises among four transient codes (AGNES, CRITEX, INCTAC and TRACE) have been carried out with typical transient experiments using uranyl nitrate fuel solution. Two sets of benchmarks were carried out based on experimental programmes performed in the TRACY reactor in Japan, and the SILENE reactor in France. TRACY and SILENE have the same geometrical features: an annular cylinder with a central void tube for a transient rod and similar operational modes for reactivity insertion. The experiments selected are representative benchmarks for low- and high-enriched uranyl nitrate solution, about 10 wt% for TRACY and 93 wt% for the SILENE core. This report provides an analysis of the benchmark results obtained with four different codes. It will be of particular interest to criticality safety practitioners developing transient codes, notably since little experimental data is available and the existing transient codes are presently unavailable to the public.

Mixed-oxide (MOX) Fuel Performance Benchmark (PRIMO)

Summary of the Results for the PRIMO BD8 MOX Rod

ISBN 978-92-64-99085-2. 40 pages. Free: paper or web.

The plutonium produced during the operation of commercial nuclear power plants or that has become available from the dismantlement of nuclear weapons needs to be properly managed. One important contribution to the management process consists in validating the calculation methods and nuclear data used for estimates concerning power systems burning mixed-oxide (MOX) fuel. Another important contribution is the improved modelling of MOX fuel behaviour in such systems. Within the framework of the NEA Expert Group on Reactor-based Plutonium Disposition, a fuel modelling code benchmark test was carried out for MOX fuel, with irradiation data on the BD8 MOX rod of the PRIMO programme provided by SCK•CEN and Belgonucléaire. This report summarises the data provided and the fuel characteristics for the irradiation, and presents the calculation results provided by the contributors.

Nuclear Fuel Cycle Synergies and Regional Scenarios for Europe

ISBN 978-92-64-99086-9. 36 pages. Free: paper or web.

Regional strategies can provide a useful framework for implementing innovative nuclear fuel cycles. The appropriate sharing of efforts and facilities among different countries is necessary in today's context, as is taking into account proliferation concerns and resource optimisation. The preliminary studies examined in this report show that the expected benefits deriving from partitioning and transmutation (P&T), notably the reduction of radiotoxicity and heat load in a shared repository, can bring advantages to all countries of the region concerned, even when different nuclear energy policies are pursued. The studies also demonstrate that regional strategies tend to favour a nuclear "renaissance" in some countries. A regional approach is proposed in order to implement the innovative fuel cycles associated with partitioning and transmutation in Europe. The impact of different deployment strategies and policies in various countries is addressed. Regional facilities' characteristics and potential deployment schedules are also discussed. Further studies should be undertaken to investigate practical issues (fuel transport in particular) and institutional issues which will, without doubt, be very challenging.

Research and Test Facilities Required in Nuclear Science and Technology

ISBN 978-92-64-99070-8. 156 pages. Free: paper or web.

Experimental facilities are essential research tools both for the development of nuclear science and technology and for testing systems and materials which are currently being used or will be used in the future. As a result of economic pressures and the closure of older facilities, there are concerns that the ability to undertake the research necessary to maintain and to develop nuclear science and technology may be in jeopardy. An NEA expert group with representation from ten member countries, the International Atomic Energy Agency and the European Commission has reviewed the status of those research and test facilities of interest to the NEA Nuclear Science Committee. They include facilities relating to nuclear data measurement, reactor development, neutron scattering, neutron radiography, accelerator-driven systems, transmutation, nuclear fuel, materials, safety, radiochemistry, partitioning and nuclear process heat for hydrogen production. This report contains the expert group's detailed assessment of the current status of these nuclear research facilities and makes recommendations on how future developments in the field can be secured through the provision of high-quality, modern facilities. It also describes the online database which has been established by the expert group which includes more than 700 facilities.

The JEFF-3.1/-3.1.1 Radioactive Decay Data and Fission Yields Sub-libraries

JEFF Report 20

ISBN 978-92-64-99087-6. 148 pages. Free: paper or web.

The Joint Evaluated Fission and Fusion (JEFF) Project is a collaborative effort among NEA Data Bank member countries to develop a reference nuclear data library for use in different energy applications. Radioactive decay data forms an integral part of the nuclear data requirements for nuclear applications. In 2005, a completely revised library, JEFF-3.1, was made available. The updated JEFF-3.1.1 Radioactive Decay Data and Fission Yields Sub-libraries were released in 2007. This report describes the development, contents and initial validation of the JEFF-3.1 Radioactive Decay Data and Fission Yields Sub-libraries, including the 2007 update, JEFF-3.1.1, of these sub-libraries.

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