NEA News

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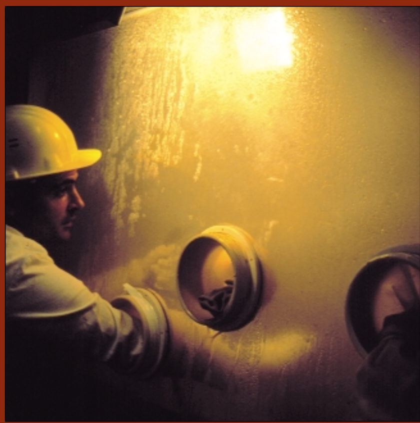

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NEA News

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The OECD Nuclear Energy Agency (NEA) was established in 1958 as the OEEC European Nuclear Energy Agency and took its present designation in 1972 when its membership was extended to non-European countries. Its purpose is to further international co-operation related to the safety, environmental, economic, legal and scientific aspects of nuclear energy. It currently consists of 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 NEA's work and a co-operation agreement is in force with the International Atomic Energy Agency.

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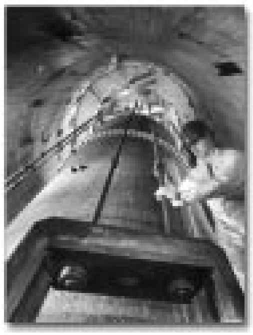
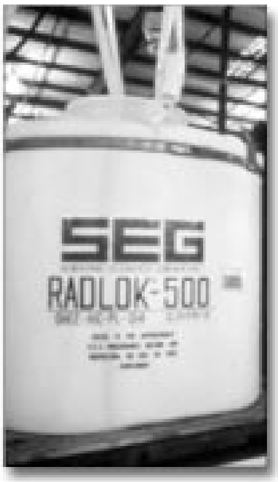
Cover page: Tunnel at Yucca Mountain (NEI, USA); Orphée research reactor (Gonin, CEA, France); dismantling and disposal (NEI, USA); dismantling at Marcoule (SYGMA, France).

Facts and opinions





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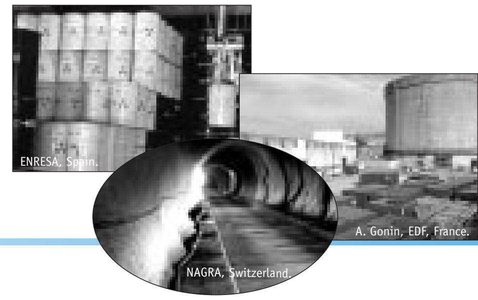
editorial

Taking care of the "waste"

Although radioactive waste arises during the course of several industrial activities, that which stems from the production of nuclear energy poses a specific challenge. In one sense it could seem inappropriate to label spent nuclear fuel as "waste" to the extent that some 96% of its contents could be reprocessed and used as fuel again. But significant amounts of waste are still generated even when a reprocessing option has been chosen, and most countries still rely on a "once-through" fuel cycle. All of these radioactive waste arisings require appropriate disposal, and their management is an issue that has attracted considerable interest among both technical specialists and the general public.

Low-level waste disposal generally poses no problems for either of these groups, with largely acceptable solutions having been adopted. On the other hand, disposal of long-lived waste has enjoyed less all-round consensus. Most technical specialists are now confident in the capacity of deep geological repositories to confine long-lived waste for the required periods without causing any harm to the environment or placing undue burdens on future generations. The general public more reluctantly shares this confidence, in some instances lacking trust in the experts, and in others remaining wary of the very long timescales involved. The regulatory authority can be an important source of objective information in these instances, as described in the article on page 15. Involving stakeholders in a stepwise decision-making process can also have significant impact on repository development (see page 18).



Waste from the decommissioning of nuclear installations also requires proper management and disposal. As most of the waste is of the low-level category, disposal options are relatively straightforward. In terms of cost, the article on page 8 recalls that dismantling and waste management/disposal generally represent a large share (one-fourth to one-third) of total decommissioning costs. It also points out that various measures and schemes are in place in each country to ensure that decommissioning funds are accumulated in a timely fashion to be available when expenses occur. Similarly, the cost of radioactive waste disposal associated with the operation of nuclear power plants is funded in most countries by a levee on the electricity generated, which is then put aside in a specially designated fund that is controlled and guaranteed by the State. The nuclear industry is one in which the "polluter pays principle" is fully accepted and in many ways legally integrated.

Luis E. Echávarri
NEA Director-General

P. Wilmer *

The economics of nuclear energy

In common with many of the issues surrounding nuclear energy, there is some truth in the popular claim that nuclear energy is "not economic", but this is far from being a universal truth. Overall, nuclear energy can be a competitive source of electricity and a realistic economic option for the future.

There are currently 362 nuclear power plants operating in OECD countries and virtually all of them compete economically within the markets in which they are situated. This is irrespective of these markets being regulated or liberalised.

Nuclear power plants are characterised by high capital costs; the incremental costs of operation are generally below the value of the electricity that the plants generate. There is also good evidence that these operational costs are being reduced. The most valuable actions being pursued and achieved by owners are increases in plant load factors, the uprating of plant capacities and the extension of plant lifetimes. For example, nuclear plants in the United States increased generation by more than 30% between 1990 and 2000 while no new plants were commissioned. Furthermore, again in the US, 10 nuclear power plants have recently received regulatory approval to extend their operating lives from 40 to 60 years; 16 applications for license renewal are under review and 27 more plant operators have expressed the intention to file a request for such renewal. All of these actions, which necessitate the investment of time, effort and knowledge, and sometimes physical investment, result in increased generation from the asset at costs close to operating costs – a very attractive business opportunity for all stakeholders.

When existing plants close, they generally do so for two reasons, one of which is economic non-viability, the second being political or social intervention. Economic non-viability usually arises because a non-recurring expenditure has to be made, the cost of which cannot be justified in commercial terms.

The choice of technology for new generating plant

Nuclear energy has not been the electricity generation technology of choice in most countries for two decades or more. There are social concerns about and political difficulties with nuclear technology that centre on the perceived safety risks, the disposal of radioactive waste and the risk of weapons proliferation. Moreover, some countries do not need to invest in any new electricity generating plants at present since consumer demand is being satisfactorily met by existing installations. But, notwithstanding these issues, what would be the economics of a new nuclear power plant?

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The most recent study published by the Nuclear Energy Agency (NEA), working jointly with the International Energy Agency (IEA), reports and analyses data provided by OECD member and non-member country governments regarding electricity generating plants to be commissioned in 2005. Levellised costs, discounting the lifetime cash flows using a rate of 5% per annum, showed that nuclear energy was the most attractive economic option by a significant margin in 5 countries out of the 18 from which comprehensive responses had been received. At a discount rate of 10% per annum, the nuclear option was never the most attractive.

Levellised cost and discount rate

The levellised cost methodology discounts the time series of expenditures and incomes to their present values in a specified base year by applying a discount rate. Applying a discount rate takes into account the time value of money, i.e. a sum earned or spent in the past or in the future does not have the same value as the same sum (in real terms) earned or spent today. The discount rate may be related to rates of return that could be earned on typical investments; it may be a rate required by public regulators incorporating allowance for financial risks and/or derived from national macro-economic analysis; or it may be related to other concepts of the trade-off between costs and benefits for present and future generations.

Source: NEA (1998), *Projected Costs of Generating Electricity: 1998 Update,* OECD, Paris [out of print].

The sensitivity of total costs to changes in the cost elements are very different. For combined-cycle gas-fired power plants, the technology of "choice" today, the cost of gas accounts for more than two-thirds of the total generation cost. Thus the outcome of a comparative analysis depends critically on the future price of gas over the lifetime of the plants. The IEA currently projects the future price of gas over the first quarter-century of this millennium as being below the level prevailing in 2000 and less than half that of 1980, in real terms. Certainly this reference projection reflects "conventional wisdom", but there is much scope for adopting an analysis based on a range of different scenarios.

On the other hand, nuclear energy costs are dominated by the capital investment. Other costs are relatively small, including nuclear plant decommissioning. Once built, a nuclear power plant offers stable electricity costs over a long period, provided that it operates successfully. The plant owner is exposed to financial risk from the construction, from regulatory uncertainty during both construction and operation and from market price uncertainty. The control of the owner's exposure to risks depends on the details of the commercial arrangements that support the nuclear power plant and it is difficult to generalise about them. However, the entities accepting these risks have to have the capacity to accommodate them and this points towards large and robust organisations or companies, including the generator. Small generators operating in a fully competitive market, probably in the private sector, may not have the appetite for investing in nuclear energy having seen the fate of all generators in the United Kingdom and in Sweden at the hands of harsh competition in the newly liberalised electricity markets.

One interesting challenge for the nuclear industry is the test of its historical approach of moving to larger and larger plants in order to achieve economies of scale. The most recent reactors commissioned in France have a 1 450 MWe capacity while the first commercial reactors built in Europe (at Calder Hall in the United Kingdom) had a 50 MWe capacity. However larger capacity means larger financial risk, and the place for this in the future is a topic of open debate. The alternative approach of reducing the size to better suit the needs of the electricity generation systems, to allow more use of factory-based manufacturing techniques and to benefit from series effects has yet to be tested.

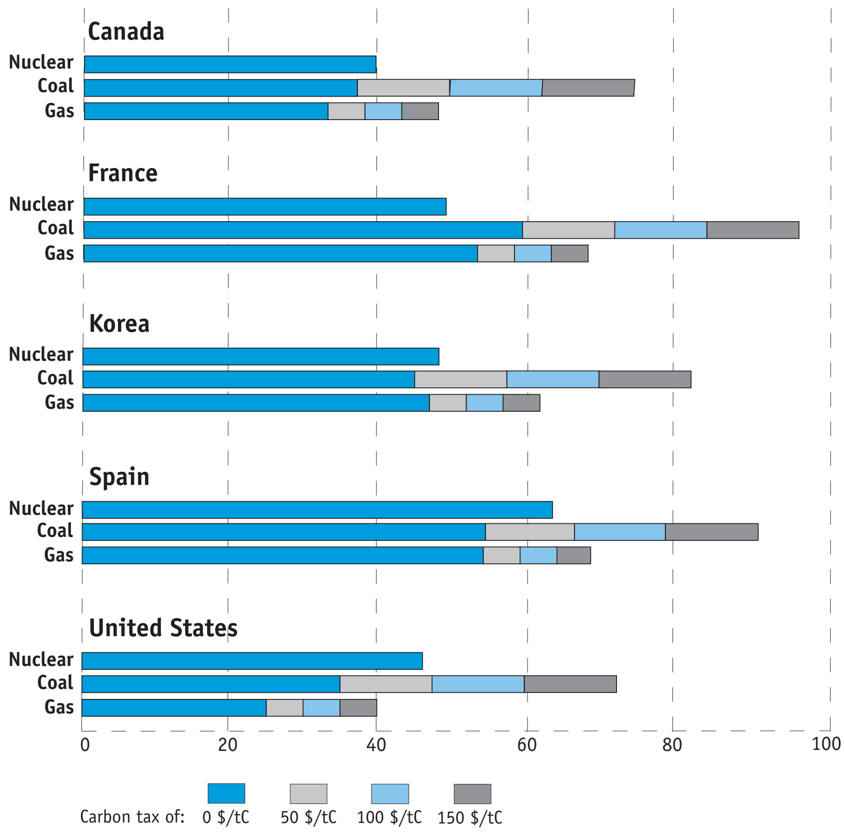
Specific national assessments conducted recently by some OECD member countries show that nuclear energy is the most economic for electricity generation, viz. Finland, France and Japan. Other countries, such as the United Kingdom, have found otherwise.

The economics of future nuclear power plants

At the heart of the future competitiveness of nuclear power plants are the capital costs, the investment needed at the outset. Obtaining definitive data on this has always been difficult but is increasingly so. Commercial confidentiality is an issue and variations of project scope and conditions make comparisons difficult. However, it is clear that the suppliers of nuclear power plants have acted to improve and speed up construction management and to simplify plant design and manufacture. The benefits of a phased programme with ongoing replication are widely recognised. The products offered today, developed through a process of evolution, involve a reduced specific capital cost (US$ or €/kWe) relative to the plants built in the past. Perhaps a 25% reduction in the current guide price of US$2000/kWe installed capacity can be achieved by the evolutionary water reactors offered, for example, by Areva (EPR) or BNFL/Westinghouse (AP1000). The ultimate test is to build a plant selected by competitive tender and TVO in Finland is currently well-engaged in this process.

For the longer-term future, the industry looks to the outcome of today's investment in research and development for new, innovative products. Investment in R&D varies greatly between OECD member countries, from ¥288 billion per annum in Japan (c. US$ 2 billion) to very little in some European countries. The current R&D focus of some key countries, including OECD members and non-members, is the Generation IV International Forum (GIF) initiated by the United States and pursued jointly by Argentina, Brazil, Canada, France, Japan, the Republic of Korea, South Africa, Switzerland and the United Kingdom. The aim of the endeavour is to share the responsibility and cost of R&D focusing on nuclear energy systems selected for their innovative characteristics and promises for tomorrow. Tomorrow is being defined in the GIF context as plants ready for deployment by 2030. Some choices have been made against specific objectives, some of which relate to economics. The intention is to reduce the specific capital cost to around half the current level, reduce construction times and reduce financial risks to a level comparable to those for other generating technologies and fuels.

Levellised electricity generation costs (10% discount rate) and the effect of carbon tax



Regarding renewable energy sources for the future as an alternative to nuclear, all citizens of the world, especially those in Europe, would welcome a large, inexpensive, safe, environmentally benign energy source for the future. However, it is far from clear that renewable energy sources can meet these ideal goals. In terms of economics, non-hydro renewable energy sources are currently expensive and most of them are intermittent, therefore requiring additional investment in back-up plant. Interestingly, renewable energy sources share a high-capital intensity with nuclear energy and therefore also carry large financial risks. It would be unwise to close our eyes to any option for the future, including nuclear energy, until the aspirations of the proponents of renewable energy sources become a welcome reality.

Broadening the economic picture

Is this all the economics story? From the point of view of governments, it is not. Energy, and electricity in particular, are key ingredients of our healthy and prosperous lives that many developing countries are missing. Its production and use have impacts, positive and negative, which reach beyond economic markets. External costs are those which are not included within the price for a product paid by the customer and consequently are borne by society. These are assessed using life cycle cost analyses and impact pathway analyses, the most comprehensive study of which, for electricity generation, is the ExternE Project, sponsored by the European Commission. The study focuses on the environmental costs of electricity generation systems and broadly shows that the external costs of the nuclear electricity generation chain are of the order of 10% of the market price of electricity; a similar figure applies to renewable energy produced from wind. However, the external costs associated with the generation of electricity by the combustion of fossil fuels (gas or coal) range up to 100% of the electricity market price. Such a discrepancy implies a weakness in today's market arrangements that needs to be speedily addressed in order to direct investment towards a more sustainable development approach.

Other aspects of the technology choices for generating electricity will also be of considerable interest to governments. These include security of energy supply, balance of trade and employment – all of which have the potential to influence national choices for electricity generation. Probably, consideration of these would enhance the competitive position of nuclear energy, were they to be quantified as external costs and internalised within the price of electricity.

Concluding remarks

Economically, nuclear energy is broadly "within the market" today. The specific individual characteristics of OECD member countries influence whether it is an attractive economic choice for new investment in generating technology in local circumstances. Sometimes, non-economic considerations are at the fore in determining national policies.

In the future, the relative economics of nuclear energy will depend on its technical development, but even more so on the evolution of renewable energy technologies, the price of fossil fuels and the importance attributed to external costs, including those associated with the environment and global warming.

Inexpensive renewable energy sources and inexpensive fossil fuels over the next 50 years do not seem to be assured. In addition, the existence of external costs must not be overlooked by governments. From the economic perspective, nuclear energy is a realistic economic option for the future that cannot be ignored. ■

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Decommissioning policies, strategies and costs: an international overview

As many nuclear power plants will reach the end of their lifetime during the next 20 years or so, decommissioning is becoming an increasingly important topic for governments, regulators and industries. Decommissioning policies and strategies vary widely at the international level, and choices in strategy may also differ. In addition, project-specific characteristics largely influence decommissioning costs. Despite this, major cost drivers can be identified.

Governments are particularly interested in ensuring that money for the decommissioning of nuclear installations will be available at the time it is needed, and that no "stranded" liabilities will be left to be financed by the taxpayers rather than by the electricity consumers. For this reason, they have sought to understand the components of decommissioning costs and to periodically review cost estimates from nuclear installation owners. Robust cost estimates are key elements in designing and implementing a coherent and comprehensive national decommissioning policy, including the legal and regulatory bases for the collection, saving and use of decommissioning liability funds.

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Industry also has an interest in perfecting its knowledge of decommissioning costs so that it may develop a coherent decommissioning strategy that reflects national policy and assures worker and public safety, while also being cost effective.

The NEA study on decommissioning

A study[1] on decommissioning policies, strategies and costs was carried out by the NEA in 2001-02, with the objectives of compiling relevant data and analysing them in order to understand how national policies and industrial strategies affect decommissioning costs, and eventually identifying decommissioning cost drivers. The scope of the study was limited to commercial nuclear power plants, excluding prototypes, demonstration plants and plants where significant incidents or accidents would have occurred. This approach was adopted in order to obtain data representative of decommissioning activities undertaken by the nuclear power industry.

Table 1. Decommissioning policy overview

Included in national policy	Share of positive answers
Definition of decommissioning	50%
Defined decommissioning end-point	50%
Mandatory timescale for decommissioning completion	25%
Decommissioning license requirement	80%
Defined radioactive waste exemption levels	60%

Twenty-six countries provided data and information through the study's questionnaire. The questions on policy and strategy targeted issues of relevance for cost estimates. The proposed detailed cost structure[2] – namely cost elements (e.g. dismantling activities or site cleanup and landscaping) and cost groups (e.g. labour or capital) – was intended to support an in-depth analysis of cost drivers. However, most respondents reported results from existing studies and estimates based on national and/or company accounting frameworks and practices, which were not fully consistent with the scope and structure recommended in the questionnaire. These limitations were taken into account in the analyses presented in the report.

The data collected include decommissioning cost estimates for a large number of nuclear power plants, representing approximately one-third of the nuclear capacity in operation worldwide. It offers a robust base for statistical analysis and overall assessment. Decommissioning cost estimates were provided for a broad range of reactor types and sizes, reflecting the variety of nuclear power plants built and operated in the participating countries. All reactor types that have been commercially deployed (PWR, VVER, BWR, PHWR/CANDU and GCR) are covered by the study. The size of the reactors considered range from less than 10 MWe to more than 1 000 MWe.

Decommissioning policies and strategies

Decommissioning policy is defined as the framework implemented by governments, including laws, regulations, standards and mandatory requirements, that imposes the background rules to be followed by the nuclear industry for decommissioning projects. National decommissioning policies were found to differ on many aspects that may have an impact on costs. Key points in this regard are summarised in Table 1, which indicates the percentage of positive answers for each topic listed.

Decommissioning strategy, as defined within the study, relates to how the owners and operators of nuclear power plants apply national policy to their specific decommissioning project. Wide variations can be noted in the strategies adopted by industries in different countries and even by different operators in the same country. Operators/owners consider a broad range of issues in choosing a decommissioning strategy, covering technical feasibility, economic efficiency, regulatory constraints and socio-political aspects.

Regarding the decision-making process, national context and local situations are often driving factors for choosing between alternative approaches. For example, the status and trends in nuclear power development in the country, the local social conditions (e.g. unemployment, development of tourism) and the expected re-use of the site are primary factors considered in determining industrial strategies for decommissioning.

In terms of schedule, the majority consider both immediate and deferred dismantling when choosing a strategy; in some countries, however, the regulatory framework allows only one option. Each of the two options, immediate and deferred dismantling, was assumed for costing purposes by roughly half of the study respondents. It is interesting to note that, in practice, immediate and deferred dismantling are not always drastically different in terms of the overall schedule of decommissioning activities. For example, some immediate dismantling strategies lead to ending decommissioning activities 40 years after shutdown, while some deferred strategies with 30 years of dormancy will lead to a similar end of activities 40 years after shutdown. This largely explains the lack of impact of immediate versus deferred dismantling on decommissioning costs.

Decommissioning costs

Decommissioning cost estimates (see Table 2) remain below 500 US$/kWe for nearly all water reactors considered in the survey. For gas-cooled reactors (GCR), the reported cost estimates are significantly higher (around 2500 US$/kWe), but it should be noted that only four cost data sets were reported for this reactor type and they refer to old reactor designs not at all comparable with the high-temperature, gas-cooled reactors (HTGR) under development today.

Dismantling and waste management/disposal generally represent a large share (one-fourth to one-third) of total decommissioning costs; each one of these two elements may reach up to 60% of total costs in some cases. Three other cost elements usually represent around 10% each of the total cost: security survey and maintenance; site cleanup and landscaping; and project management, engineering and site support. The other elements seldom exceed 5% of total decommissioning costs.

Regarding waste management and disposal, the weight of radioactive waste arising from decommissioning activities is around 10 tonnes per MWe for any reactor type, except for the gas-cooled reactors for which it is ten times higher, around 100 tonnes per MWe. This is one of the reasons why decommissioning costs do not seem to vary significantly according to the type of water reactor considered.

Decommissioning is a labour-intensive activity and labour costs may be a significant component of total decommissioning costs. However, on the basis of cost data sets provided for the study, there is no evidence of correlation between average national manpower costs and total decommissioning costs. This might be the result of industry strategy adaptation, shifting from manual intervention to automated equipment when and where high labour costs make it economically efficient.

Table 2. Summary of decommissioning cost estimates

Reactor type *(no. of data sets)*	**Average cost** *(US$/kWe)*	**Standard deviation** *(US$/kWe)*
PWR (21)	320	195
VVER (8)	330	110
CANDU (7)	360	70
BWR (9)	420	100
GCR (4)	>2500	-

Decommissioning cost drivers

The study's findings on cost drivers are only tentative owing to the variability in coverage and comprehensiveness of responses. However, they generally confirm earlier national and international analyses and publications. In particular, they highlight the importance of project-specific characteristics and issues in the understanding of decommissioning cost elements.

The main factors identified as having minor impacts on decommissioning costs are: type and size of the reactor (GCRs excepted); immediate or deferred dismantling option; and unit labour costs. The major cost drivers concern: scope of decommissioning activities; regulatory standards including waste classification and clearance levels; site conditions and re-use; and radioactive waste disposal.

The scope of decommissioning activities taken into account in cost estimates, including the

UKAEA, United Kingdom

Dismantling operations at a nuclear power plant in the United Kingdom.

assumed starting and end-point, obviously has a major influence on total cost. This scope is largely delineated by national policy. Analysing in detail the relationship between policy changes and costs could provide valuable information to policy makers. Such an analysis would, however, require more detailed information on national decommissioning policy and cost estimates than was available for the study.

Regulatory standards in force – including clearance levels, allowable radiation doses to workers and the public, environmental norms and standards – define the framework and boundaries of decommissioning activities and have a major impact on the cost of decommissioning. For example, maximum acceptable dose to workers has a direct impact on manpower requirements and the cost of labour. Environmental regulations and mandatory decommissioning end-points have an impact on the scope and schedule of decommissioning activities, which in turn are key cost drivers.

Site-specific conditions of a decommissioning project that have an impact on cost include the number, type and status of units located on the same site and the intended re-use of the site (for example, nuclear facilities or a recreation park). The scope and end-point of decommissioning activities vary widely depending on such site-specific issues as the continued operation of nuclear facilities during and after the unit under consideration is decommissioned.

The quantities and specific characteristics of radioactive waste arising from decommissioning are a major cost driver. An in-depth study in this field would be needed to identify and analyse separately the impacts of regulations (clearance levels), technical progress (plant design and operation, waste treatment) and socio-political context (cost and implementation of waste disposal facilities).

Providing for future decommissioning costs

The information provided for the study shows that in all countries, decommissioning costs are robustly estimated and thoroughly analysed by operators, regulators and governments. Cost estimates based upon engineering models and feedback from experience are carried out, regularly updated and often audited by independent bodies. These estimates are used in particular to assess the amount of decommissioning funds necessary. Various measures and schemes are in place in each country to ensure that the decommissioning funds are accumulated in a timely fashion to be available when expenses will occur. ■

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B. Kaufer*

Improving the interface between nuclear regulators and operators

Ensuring that nuclear installations are operated and maintained in such a way that their impact on public health and safety is as low as reasonably achievable has been and will continue to be the cornerstone of the nuclear safety landscape. But it is clear that this landscape is changing. The introduction of competition into electricity markets, technological advancements and government oversight are a few of the many factors creating challenges today.

The number of players involved in nuclear electricity generation is considerable, but two key players stand out when it comes to the issue of nuclear safety: the nuclear regulator and the nuclear industry. While the industry is responsible for safety, it is the regulator who ensures that licensees operate their plants in an acceptably safe manner. Although many fora are organised in this area, few bring together top-level participants from regulatory organisations and the nuclear industry for an exchange of views with a goal of reaching common understandings.

Recognising this, the NEA Committee on Nuclear Regulatory Activities (CNRA) and the World Association of Nuclear Operators (WANO) held a joint international forum in June 2002. The forum sought to improve communication between the parties as well as understanding of the rationale used by each group. Discussions focused on three areas of interest: market competition, asset management, and measuring and communicating safety performance. In order to better understand the results of these discussions, it is helpful to know how each of these terms was approached at the forum.

Market competition – In the present environment, issues such as industry restructuring, market liberalisation, grid stability, safety performance, maintaining competence, management of change and impact of regulatory changes are primary drivers to changes in industry practices, which in turn require the regulator to discern the associated impacts on regulation and safety. A key aspect of market competition is the speed of change, which brings about changes in what industry or regulators perceive, and may result in added tensions or pressures on both. Other issues include organisational changes and the increased demand by the public to ensure safety.

Asset management – The nuclear industry needs to maintain adequate resources to carry out its work both now and in the future, while at the same time maximising its economic return. A key element in addition to financial issues (i.e. liabilities, relationships, internationalism, etc.) and physical questions (life extension, periodic safety reviews, decommissioning) is human assets. The need to maintain capability, skills and staff is considered to be a very important issue.

Measuring and communicating safety performance – It is essential for any organisation to have relevant indicators of its performance. Both nuclear regulators and the nuclear industry have made numerous efforts in the past years to

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establish systematic, meaningful and reliable ways to measure safety performance. Both parties have established systems for collecting information on safety performance, with each recognising that there are pros and cons in using performance indicators. Issues needing to be addressed include: ways to share this information; what types of indicators (e.g. lagging or leading) are used; and transparency and openness in relation to market competition and as part of a safety management system.

Forum discussions

Throughout the forum, participants regularly sought ways to define the respective roles of operators and regulators; develop usable performance indicators, especially in the management area, and improve mutual confidence between both parties. They also addressed the control of outside contractors, the regulator's role and competence with respect to the operator's organisational and staffing matters, and the need to react to international pressures to achieve more harmonised nuclear safety standards.

Both regulators and operators noted that the economic pressures of competition in electricity markets have led to greater focus on efficiency in plant operations, raising some concern about sustaining efforts to maintain a good nuclear safety culture. It was clear from the discussions that market competition has created challenges to safety for both regulators and operators. Encouragingly, both sides see trends that liberalisation can actually lead to better safety performance, but they also acknowledge the need for continued caution and vigilance.

Regarding asset management, regulators and operators alike stressed that one of the biggest challenges in the future would be to have reliable and adequately trained staff. Work is needed, both nationally and internationally, to sustain a skilled knowledge base. Doing so will be a key test of the success of joint efforts between regulators and operators.

Measuring safety performance was a more difficult area in which to achieve consensus because of the different approaches taken by each side. It was recognised that sharing safety performance information would be greatly beneficial to both regulators and operators, especially in improving the effectiveness of their responses to events. This is possible provided a firm understanding is reached on how the information is to be used by both sides. Two very difficult areas were also discussed: performance indicators related to management issues and the continuing problem of identifying performance indicators that help reveal worsening safety situations. The general problem of operators (and regulators) using performance indicators as targets was also recognised.

Open and clear communication with the public has largely been a priority and has been achieved by both parties. The remaining challenge is to ensure that not only are improved messages delivered, but also that they are understood and believed.

Concerns remain

The general sentiment at the end of the meeting was that coming together was a beginning, remaining in contact would be progress, and working together would be the demonstration of success. The forum enlarged the scope of existing relationships between regulators and licensees from a national perspective to an international interface across borders.

A real concern remains, however, about the measurement and communication of safety performance in the modern era of market competition and openness. Industry is worried about the regulators misusing the results of peer reviews or performance indicators, either to take precipitate regulatory action or to make premature comments in public. To a large extent this goes right back to a mutual appreciation of each other's roles in the overall safety system and how this has been altered by the new circumstances that operators and regulators have to face.

Other concerns include:

- ***Safety***: Is there agreement on the issue of safety culture? How does the operator assess it and where does the regulator fit into the picture? How safe is "safe enough" and how can the regulator and the operator reach agreement?
- ***Economic pressure***: It can be good for safety, but there needs to be awareness that organisational changes can have negative consequences for safety.
- ***Regulation***: Good co-operation between the regulator and operator is necessary to ensure that resources are targeted at real safety issues, but the regulator also needs to retain the confidence of other stakeholders, particularly the public.

- ***Public demands***: Both nuclear regulators and the nuclear industry need to understand how to satisfy the public's ever-increasing demands for openness without damaging the operator's commercial interests or financial standing.

Both the NEA and WANO recognised that communication is a key area in which regulators and industry could work together to ensure that other stakeholders, that is government and the public, not only openly receive information but are also able to understand what it means and believe it. The forum succeeded in initiating a consensus-building process for regulators and operators for the first time in a truly international setting. The next step is to begin working together to increase co-operation and develop common approaches, while respecting the independence of each party.

Future co-operation

Several practical recommendations were developed by the forum participants for future co-operation:

- The NEA, through its two safety committees (the CNRA and the CSNI), should review the results of the forum and prepare reports of interest and use by their member countries as appropriate. For example, the CNRA is currently focusing on the subjects of analysis of operating events, accident precursors and near misses, and the continuing development of safety performance indicators. WANO is considering developing guidance for plant operators on change management, human performance, operational decision making and other specific issues as they develop. Both organisations commit to providing information on their respective (future) programmes of work and to exchange information in the future, when possible.
- Participation of WANO members in selected meetings or activities of the NEA committees or working groups, as agreed on a case-by-case basis, would help maintain a co-operative relation. The mutual convenience of holding a follow-up forum should be considered in two to three years.

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- The NEA and WANO should exchange information on concepts, such as the performance indicators they develop or their criteria for event reporting, and might define a protocol for exchanging such information.
- The NEA and WANO recognise that knowledge management (concerning in this case personnel ageing and maintaining technical competencies) is an area of concern to both organisations and to other interested parties. They favour the development of programmes aimed at attracting and retaining young people into the nuclear field and maintaining technical expertise in the future. Both organisations agree to exchange information on initiation of actions taken on knowledge management.

In line with the latter recommendation and based on the positive feedback received, the NEA plans on holding another Regulator/Industry Forum in 2004 (RIF 2004). The topic of this forum will be "Maintaining a Sound Basis for Continued Safe Nuclear Power Plant Operation". The main focus will be on one of the key issues raised in the 2002 forum: the use of contractors.

C.R. Lopez, C. Pescatore *

A new profile for regulators in radioactive waste management

Institutions involved in the long-term management of radioactive waste are facing a rapidly evolving environment stemming from such influences as societal changes, new information technology and new roles for the media. This is taking place at the same time as some national programmes evolve from research and development to site selection and implementation of a repository, whilst others are reviewing and defining their policies in the waste management area. As in many environmental areas, a demand for public participation in decision making leads to a need for new approaches to involving stakeholders. The NEA Forum on Stakeholder Confidence (FCS) examines the societal and decision-making context of long-term radioactive waste management, notably as regards solid waste disposal. Several features of this context have particular significance for regulatory authorities.

Generally speaking, the regulator's responsibilities are to (a) define radiation protection and nuclear safety requirements; (b) issue guidance on safety assessment methodology and documentation; (c) review the implementer's safety analysis as a basis for licensing waste management and disposal activities and facilities; and (d) inspect and review construction, operation and closure of nuclear facilities to ensure compliance with licensing conditions.

The FSC observes that amongst all the institutional actors in the field of long-term radioactive waste management, it is perhaps the regulatory authorities that have restyled their roles most significantly. In partaicular, modern societal demands on risk governance and the widespread adoption of stepwise decision-making processes have already led to changes in the image and role of the regulators. Also, legal instruments reflect and encourage a new set of behaviours and a new understanding of how regulators may serve the public interest.

Regulators: providing a service to the public

The technical regulators have a mission of public service, are "guarantors" of safety and are the "peoples' expert", or peoples' resource, on safety concerns. They need to act and be seen as independent overseers of the quality of the work and the credibility in the decision-making process. Independence, competence and effectiveness of the regulator are crucial to public trust and confidence in the national radioactive waste management programme, especially as regards high-level waste (HLW) disposal.

Regulators should thus establish good contacts with the different stakeholders. Open channels of communications should be maintained with the

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public, implementers, government departments, parliament, concerned action groups and others. Appropriate mechanisms of dialogue must be found with the different stakeholders. In particular, the regulators should be involved early in the process of facility siting and collaborate with the potential host community/ies to the extent that this is compatible with the national regulatory regime.

Successful experiences in facility siting have shown that active regulatory involvement is needed and is also possible without endangering the independence and integrity of the regulatory authority. For example, thanks to their early involvement and commitment at the local level, the regulatory authority of the Nordic countries have come to be seen by the municipalities as "the independent expert of the public" and "competent and responsible supervisors of safety".

Regulatory process: gradual progress and public involvement

A stepwise decision making and implementation process implies a stepwise regulatory process. This kind of regulatory process facilitates the development of regulations in a gradual way, starting from very general principles and ending with the guidance applicable to a licensing review. In this way, the job of regulating the development and implementation of a radioactive waste disposal facility, for instance, is intrinsically one of gradual learning and refinement. Accordingly, rules set at one step may be modified or updated at a later stage, although regulators must clarify the reasons and basis for changing regulations at later stages of repository development. (For further details regarding stepwise decision making in radioactive waste management, see the article on page 18.)

In order to preserve flexibility in a decision-making process that can last decades, regulators should strive to avoid over-prescriptive rules too early. This attitude implies in turn a well-structured and formalised interaction process between implementers, regulatory authorities and other stakeholders that secures the societal trust mentioned above. A potential issue that could emerge is whether the level of knowledge is adequate to provide the necessary input for the technical and societal decision at each stage in the stepwise development process. A pragmatic response to this question can be given: in the early stages, only a preliminary safety appraisal is needed stating that nothing has been found that would raise doubts about the possibility to achieve the required safety level.

The process of rule making and its application to facility site selection and licensing should be transparent and comprehensible. This implies an open process in which the public and other stakeholders can comment on the approaches used by the regulators:

- The "rules of the game" for the regulatory process should be known as soon as possible, and in any case in advance of a licensing application.
- Ideally, the general public should perceive the overall system of regulation, including the formulation of relevant policy by government, as being impartial and equitable.

However, since there are decisions that are the exclusive responsibility of the regulatory authorities, the regulators should determine and inform in advance when, where and how public and other stakeholder input can be accommodated. The regulators should also communicate the basis of their decisions. In any event, public involvement in the regulatory process will be an area of continuing learning.

Confidence and public trust

Public trust is based both on track record and on perceived morality and values. A good track record would suggest, from experience or evidence, that certain future events would occur as expected. A perception of such attributes as reliability, honesty, veracity, fairness and strength of a person or institution would further allow a certain degree of delegation to be given. Public trust is thus necessary to further legitimate the mission and role of the regulators, in the eyes of the public.

A number of organisational and behavioural features appear essential to building confidence and meriting public trust. Among these are:

- *Openness*: being active in providing information about decisions, policies and questions related to safety. Openness is also a matter of being prepared to answer questions, as well as to discuss and to exchange views with the public or various organisations. Communications need to be open and honest. Open channels of communication must be maintained.
- *Clarity*: demonstrating a commitment to openness through efforts to communicate in ways that are clear and understandable to the broader public. The use of plain language to explain

safety, institutional and procedural concepts is essential for fostering the understanding and transparency necessary for building trust.

- ***Accountability***: in the sense that regulators must be prepared to have their actions and decisions probed and questioned in public fora.
- ***Independence***: being independent of the nuclear energy industry in regard to licensing decisions, and of any other organisations likely to be affected by such decisions. Independence has to be demonstrated by visible actions.
- ***Competence***: both statutory and effective. Statutory competence is granted by the mandate defined for regulators in the national programme. Effective competence relies on the training of regulatory staff and the resources of their institution. The regulatory staff must have the required expertise and sufficient resources for careful scrutiny of the implementer's proposals and arguments. Achieving and maintaining adequate, effective competence within regulatory authorities means that they must be able to attract and retain capable staff.

Dialogue and interaction

In order to gain public confidence and trust, all the relevant regulatory authorities, including government, need a long-term strategy for public communication as well as for interaction with other stakeholders. A prerequisite in defining the communication strategies with stakeholders and to address issues of real interest *is to listen to their concerns and expectations*.

Public concerns have turned out, in many cases, to be different from what the technical experts regard as the most relevant concerns. In order to increase public confidence in their mandate, the regulators must understand the social concerns and how to address them. Studies and research on social concerns should thus be the starting point in addressing regulatory public information and defining stakeholder communications strategies. Indeed, risk perception, values and interests of the public and different stakeholders have been the subject of research by a number of regulatory organisations.

Since local authorities are key decision makers in any facility siting process (and even more so if the municipalities participate on a voluntary basis, or have veto rights, such as in Sweden and Finland regarding repositories), they are natural intermediaries for dialogue with the technical regulatory authorities. In the first instance, the technical regulator's role should be one of collaboration, acting proactively alongside the municipalities. The objective is not to gain public acceptance of a project but to build up the regulator's credibility and gain public confidence as well as to provide national and local decision makers with the necessary information on safety matters.

Communication with the public and the news media is a matter of particular importance, as they are both an audience in themselves and a channel for communicating with other audiences. How to communicate with the public is not a simple subject because of the limitations in translating technical language for public understanding. In any event, communication requires the organisation's commitment to continuous learning: training in risk communication and in conducting public meetings is necessary. Thus, in addition to the regulatory control functions, public information should be a key function of regulators. In fact this is stated in several legal instruments having served to create regulatory bodies and is included as a goal in regulatory strategic plans.

The regulatory authority, as a body with independent functions, should provide independent, neutral, balanced and factual information about issues related to safety. Indeed, most of the technical regulators have the obligation both to make regular or periodic reports and to inform stakeholders when asked. Consequently regulators have to be prepared to respond. This means that they should position themselves on questions of debate and issues of public interest (e.g. waste disposal alternatives and options, general feasibility of disposal, retrievability, etc.).

Conclusions

The traditional position worldwide has been that regulators should not be too intensely involved with the waste disposal programme until the actual licensing process begins, since their independence might be legally compromised. This position is gradually changing towards a more active and visible role in the pre-licensing steps.

The regulatory process is part of a broader decision-making system. Culture, politics and history vary from country to country, providing different contexts for establishing and maintaining public confidence. However, an open, stepwise regulatory process led by a respected regulator can give confidence that the implementer's proposals are subject to detailed technical scrutiny on behalf of the public. ■

C. Pescatore, A. Vari*

Stepwise decision making for the long-term management of radioactive waste

The context of long-term radioactive waste management is being shaped by changes in modern society. Values such as health, environmental protection and safety are increasingly important, as are trends towards improved forms of participatory democracy that demand new forms of risk governance in dealing with hazardous activities. These changes in turn necessitate new forms of dialogue and decision-making processes that include a large number of stakeholders. The new dynamic of dialogue and decision-making process has been characterised as a shift from a more traditional "decide, announce and defend" model, focused on technical assurance, to one of "engage, interact and co-operate", for which both technical assurance and quality of the process are of comparable importance to a constructive outcome. Consequently, the scientific and engineering aspects of waste management safety are no longer of exclusive importance. Organisational ability to communicate and to adapt to the new context has emerged as a critical contributor to public confidence.

In the new decision-making context it is clear that (a) any significant decisions regarding the long-term management of radioactive waste will be accompanied by a comprehensive public review with involvement of a diverse range of stakeholders; (b) the public, and especially the local public, are not willing to commit irreversibly to technical choices on which they have insufficient familiarity and understanding; and (c) any management options will take decades to be developed and implemented, which will involve stakeholders who have not yet been born. Thus, a "decision" no longer means opting for, in one go and for all time, a complete package solution. Instead, a decision is one step in an overall, cautious process of examining and making choices that preserve the safety and well-being of the present generation and the coming ones while not needlessly depriving the latter of their right of choice. Consideration is thus increasingly being given to the better understanding of concepts such as "stepwise decision making" and "adaptive staging" in which the public, and especially the most affected local public, are meaningfully involved in the planning process.

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Features of a stepwise decision-making approach

The key feature of a stepwise decision-making concept is a plan in which development is by steps or stages that are reversible, within the limits of practicability. In addition to the institutional actors, the public is involved at each step and also in reviewing the consequences of previous decisions. This is designed to provide reassurance that decisions may be reversed if experience shows them to have adverse or unwanted effects. Discrete, easily overviewed steps facilitate the traceability of waste management decisions, allow feedback from regulators and the public, and promote the strengthening of public and political confidence. They also allow time to build trust in the competence of the regulators as well as the implementers of a waste management project. A stepwise approach to decision making has long been implemented in national waste management programmes, e.g. since the early eighties in the USA and in the Scandinavian countries. However, despite the early implementation of the stepwise approach to decision making, the subject has not been widely developed and debated. In particular, accepted guiding principles have not yet been formulated, the roots of any such process in empirical social science research have not been fully reviewed, nor the difficulties of its implementation analysed. A satisfactory analysis might not have been possible until recently, however, before more experience was accumulated. The NEA Forum on Stakeholder Confidence has examined the above points in a report[1] soon to be released, whose key messages are summarised hereafter.

➩ ***Decisions are already being made in a stepwise and participatory fashion and there is thrust to increase public participation in decision making.***

Decisions are already being taken – and progress towards radioactive waste management solutions is already being made – in a stepwise fashion. Governments and the relevant institutions are incorporating provisions that favour flexibility in decision making, such as reversibility of decisions and retrievability of waste. In addition, governments and the relevant institutions are increasingly implementing instruments of participatory democracy that will require new or enhanced forms of dialogue amongst all concerned parties. For example, partnerships are created with local communities or communities are given means to interact significantly with the decision-making process. These arrangements promote the building of trust in decision makers and implementers.

➩ ***Stepwise decision making requires the reversibility of decisions.***

Reversibility denotes the possibility of reversing one or a series of steps at any stage of a programme. Such a reversal, of course, must be the result of careful evaluation with the appropriate stakeholders. This implies a need for review of earlier decisions, as well as for the necessary means (technical, financial, etc.) to reverse a step. Reversibility also denotes the fact that fallback positions are incorporated both in the long-term waste management policy and in the actual technical programme. In the early stages of a programme for waste disposal, for instance, reversal of a decision regarding site selection or the adoption of a particular design option may be considered. At later stages during construction and operation, or following emplacement of the waste, reversal may involve the modification of one or more components of the facility or even the retrieval of waste packages from parts of the facility. Thus, reversibility in the implementation phase requires the application of a retrievable waste management technology.

Not all steps or decisions can be fully reversible, e.g. once implemented, the decision to excavate a shaft cannot be reversed and the shaft "un-dug". On the other hand, these decisions can be identified in the process and used as a natural hold point for programme review and confirmation. Reversibility is thus also a way to close down options in a considered manner. If, for instance, in repository development the need to reverse course is carefully evaluated with appropriate stakeholders at each stage of development, a high level of confidence should be achieved, by the time a closure decision is to be taken, that there are no technical or social reasons for waste retrieval.

➩ ***Competing requirements of technical safety and societal control are to be reconciled in long-term waste management.***

Due to the extremely long-lasting potential danger of radioactive waste, the primary feature that waste management facilities should demonstrate

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Involving stakeholders in a stepwise decision-making process can have significant impact on repository development.

is long-term safety. At the same time, several stakeholders demand future controllability and retrievability of waste when these are placed in underground repositories. Only a step-by-step approach to technical implementation can assure that the competing requirements of safety and controllability may be met simultaneously, and that robust systems for waste management may be established. Such robust systems include monitoring during characterisation, operation and, in the case of final disposal, the post-operational phase. In response to the competing requirements of technical safety and societal control, many implementing organisations are focusing their efforts on developing a final repository from which the waste is retrievable. In some cases retrievability is also a legal requirement.

Public involvement and social learning processes are facilitated by a stepwise approach.

There is significant convergence between the approach that is being taken by the practitioners of radioactive waste management and the indications received from field studies in social research. Empirical research studies in social science identify confidence in the radioactive waste management methods and trust in the decision-making and implementing institutions as key factors of public acceptance. These studies also indicate that gaining familiarity with, and control over, radioactive waste management technologies and institutions are crucial for building up trust and confidence. Familiarity and control are to be gained through public involvement and social learning processes. Therefore, bottom-up approaches are proposed, where decision makers and other stakeholders are advised by scientific experts, but at the same time, decision makers and experts consider the objectives, needs and concerns defined by stakeholders. Bottom-up approaches are largely facilitated by stepwise procedures that provide sufficient time for developing, through deliberation, discourses that are both competent and fair.

Competing social values exist and lend complexity to decision making.

Research on organisational management suggests that competing values inevitably need to be embodied in societal decision processes for these to be successful, and that the dominant values may change over time. For example, in the past, decisions related to radioactive waste management were dominated by a technical command-and-control approach, focusing primarily on finding technically optimal solutions. Later, this approach has given way to an individual-rights orientation, with a focus on participation and on reaching decisions that have community support, even if they may not result in optimal solutions initially chosen by the experts. When participation and community support are accommodated, a further shift is then seen in seeking distributive equity. The tension that exists between competing values like technical efficiency, community support and distributive equity, lends complexity to decision-making processes. Research indicates that it is impossible to satisfy all the competing values by an idealised decision-making process. In a highly developed democratic society, however, all desired criteria should be accommodated at least to a degree.

Overarching principles of public involvement, social learning and adaptive decision making are emerging from practical experience and social research.

A consensus appears to emerge from the experience in both social research and practical radioactive waste management. Three overarching principles are the essential elements of any decision making that seeks broad societal support, namely:

- public involvement in decision-making processes should be facilitated, e.g. by promoting interactions between various stakeholders and experts;
- social learning should be facilitated, for example by promoting constructive and high-quality communication between individuals with different knowledge, beliefs, interests, values and world views;
- decision making should be iterative and provide for adaptation to contextual changes.

In the radioactive waste management context, a set of specific action goals should be targeted.

A set of goals specific to the radioactive waste management context may be stated as a way of translating into action the principles outlined above. In particular, in order to identify and implement solutions that are widely regarded as legitimate, it will be important:

- to have an open debate and decisions on the national policy regarding energy production and the future of nuclear energy;
- to develop a broad understanding that the status quo is unacceptable and that an important problem needs to be solved;
- to define clearly the goals of the waste management programme, including the source, type and volume of waste to be handled;
- to define a technically and politically acceptable waste management approach;
- to identify one or more technically and politically acceptable site(s) for a waste management facility;
- to negotiate tailor-made compensation/incentive packages and community oversight schemes with host and neighbouring communities;
- to implement decisions by fully respecting agreements.

Implementing a stepwise process raises a number of methodological issues to be resolved.

Long-term solutions to manage radioactive waste will typically take decades to be implemented. Incorporating the views of national, regional and local stakeholders and allowing for the integration of their views will likely be difficult to implement in the decision-making process. In particular, progress can no longer be expected to be linear when an iterative approach is used.

The concrete arrangements for sketching out and agreeing on decision phases, for selecting and involving stakeholders in a participatory process, and for adapting institutions to meet long-term expectations, will require careful planning and tuning in each national context. Criteria will be needed for balancing the social sustainability and the efficiency of a process made more lengthy and uncertain by added decision checkpoints. It will be important that focus and attention are kept with time and that a guarantor of the process be properly chosen. Continued reflection and exchange on an international level can make a positive contribution to these efforts. ■

Reference

1. NEA (forthcoming), *Stepwise Decision Making in Radioactive Waste Management*, OECD, Paris.

T. Lazo, S. Mundigl*

Nuclear emergency management: what's new?

Activities in the area of nuclear emergency management have flourished over the past several years. Through the use of internationally organised, multinational drills, a wealth of experience and knowledge have been gained at both the national and international levels. The lessons learnt primarily concerned the early, urgent-communication phases of nuclear emergencies, and are currently in the process of being consolidated and incorporated into national structures and approaches. While communication and data management technologies continue to advance, multinational exercises are becoming more routine and tutorial. The focus of current work is thus shifting towards later accident phases, particularly to the mid-term phase, when control has been regained of the emergency situation but the accident's consequences have yet to be addressed.

In addition to these "classic" nuclear emergency response interests, since the 11th of September 2001 national authorities have been concerned with accident response capabilities in case of terrorist acts that might involve radiation. They have notably sought to verify that existing emergency response structures, plans and capabilities are adequately flexible to address the results of terrorist activities. This, in turn, has drawn attention to the physical security of large radiation sources and of nuclear installations.

Emergency exercises and lessons learnt

From the modest national and international nuclear emergency response structures and capabilities of the pre-Chernobyl era, significant and sustainable improvements have been achieved. This has not been, however, without significant efforts. Recognising the need to improve international communication and co-ordination following the Chernobyl accident, the Conventions on Early Notification and on Assistance were developed through the International Atomic Energy Agency (IAEA) and quickly ratified by a majority of countries. The European Commission also issued a Directive to its Member States requiring accident notification and public communications. However, to assist countries in improving their international capabilities, the NEA held the first International Nuclear Emergency Exercise (INEX 1) in 1993. This table-top exercise brought together national nuclear emergency response organisations to address a simulated accident at a fictitious reactor near the border of two fictitious countries. The results of this exercise highlighted the need for more detailed study of international issues, and led the NEA to develop INEX 2. This more ambitious drill used real national and international emergency response centres, their hardware, their procedures and their personnel to address, in real-time, a simulated accident at a real reactor. Four

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such exercises were performed in the INEX 2 series between 1996 and 1999, with the active participation of the IAEA and the EC. Finally, the INEX 2000 exercise was carried out in 2001, similarly to the INEX 2 exercises, but with the principal objective of testing the implementation of lessons learnt from INEX 2.

The experience from these exercises can be broadly divided into the areas of communications and emergency response structural improvements. At the national level, it was recognised that the communication of accident-related information to other countries was of strategic importance. This came from the realisation that, even for accidents with effects only within one country's national borders, other countries would be very interested in the health and safety of their citizens in the affected country, in the transport of goods from the affected country, in the movement of people (by train, plane or car) into and out of the affected country, and numerous other health and safety issues related to the general "interconnectedness" of the modern world and its infrastructures. In addition, in an age of global news communication, it was concluded that without accurate, verified information, governments and their structures could be seen as "out of touch", thus eroding social confidence in a government's ability to appropriately protect its citizens. For these strategic reasons, national governments made international agreements (the conventions and directives mentioned above) to formalise the requirement to communicate. To implement this, and based on the experience from exercises, the emergency management community focused on more appropriately addressing the information needs of decision makers. This involved clearly identifying the types and formats of information that should be supplied at the various stages of an accident to facilitate decision making by government officials. Further, the technological mechanisms for collecting, transmitting and formatting accident-related information were improved, moving from telex and fax communications to increasing use of the worldwide web and electronic mail.

In parallel to the need for better and more tailored communication and information, the co-ordination of actions was identified as a policy objective. In border regions, the co-ordination of urgent countermeasures for population protection was seen as needed to prevent affected populations from negatively perceiving "different levels of protection" in adjoining areas separated by a simple national border (two sides of a river for example) when such differences have been established for valid reasons. Local cross-border ties were reinforced as a result of this experience, and joint, local exercises are increasingly common. On a more international scale, some level of co-ordination of such things as travel and trade restrictions or alerts was seen as being in the interest of all affected and non-affected countries. Networks of national and international response organisations, connected through modern electronic means, have been improved to facilitate such co-ordination.

The INEX Series

1993:	INEX 1
1996-1999:	INEX 2
2001:	INEX 2000
2004+:	INEX 3

At the national level, these lessons have incited many governments to improve and streamline their national decision-making processes and structures in order to appropriately collect and diffuse all needed information. This recognition of the strategic importance of such nuclear emergency management structures, with the concomitant implications for resources, has led to changes and improvements at the national and international levels.

A shift in focus

While the experience and lessons from large-scale nuclear emergency exercises continues to be internalised, national and international strategic focus is shifting to other areas. Notably, since the terrorist attacks on the 11th of September, significant efforts have been made to analyse potential radiological threats, and to assure that existing nuclear emergency response structures and processes are sufficiently flexible to appropriately address these threats. Specific training and procedures have been developed nationally, as needed. Even before the terrorist attacks, however, the radiological protection community was increasingly focusing its attention on accidents with large radiation sources, such as those used in industrial radiography, medical cancer therapy machines or research institutes.

Apart from the Chernobyl accident, where 31 fire fighters died of radiation poisoning, no nuclear workers or members of the public have ever died as a result of overexposure to radiation due to a commercial nuclear reactor accident. On the contrary, most of the serious radiological injuries and deaths that occur each year (two to four deaths annually and many more exposures above regulatory limits) are the result of exposures to large, uncontrolled radiation sources. These sources often come from abandoned medical clinic or industrial radiography equipment, and are often found by unsuspecting individuals who would like to sell them as valuable scrap metal. Better control of large sources and a more efficient network for the exchange of information regarding lost sources has been developed through the IAEA, and several major international conferences have been devoted to these issues. The new threat of terrorist attacks only heightens the need for great vigilance in the protection and control of such large and potentially dangerous sources of radiological hazard. It also bears noting that, in conjunction with concern over terrorist threats, much national attention has been devoted to the physical security of nuclear installations.

Less urgent, but no less important, is the desire by the nuclear emergency management community to better master response during the mid-term of a nuclear accident. This period follows the urgent phase before a release and continues until the accident facility is brought under control and releases end. The characterisation of contamination deposition may not be fully complete at the beginning of this mid-term phase, but urgent countermeasures (e.g. evacuation, sheltering and the use of stable iodine) have been implemented as demanded by the urgent accident phase circumstances. During this period, agricultural aspects will be increasingly important, and the involvement of stakeholders in decision-making processes will be significant. Evacuees will want to return to their homes and businesses; individuals from the affected areas will wish to know with certainty their exposures and risks; cleanup activities will begin and corresponding waste will need disposal. A multitude of practical questions will arise during this period, and policy, structural and procedural aspects of mid-term emergency planning must be in place for governments to respond appropriately. As mentioned earlier, social trust in government as well as its institutions and officers could well be threatened should mid-term responses inadequately address the needs of stakeholders. For this reason, nuclear emergency management specialists are now focusing on identifying the details of the types of issues that will arise, and on developing effective implementation processes and structures for their resolution.

Forthcoming NEA activities on nuclear emergency management

The NEA Committee on Radiation Protection and Public Health (CRPPH), through which the INEX exercises have been organised and analysed, is addressing some of the above-mentioned issues through its Expert Group on Nuclear Emergency Matters. The CRPPH is focusing its efforts on developing nuclear emergency exercises to assist response organisations to better meet the needs of their national decision makers and has entrusted its Expert Group with designing the INEX 3 exercise. Although not yet finalised, this exercise will be a table-top exercise, similar to INEX 1. The scenario to be used will involve a significant contamination "footprint" from an unspecified source, and the actions taken and results of the urgent response phase will be documented as a starting point for the exercise. The focus of INEX 3 will then be on response to agricultural issues arising as a result of the contamination. Depending upon the interests of the country participating in the exercise, some urban contamination issues, again in the mid-term phase, may also be addressed. As this is a table-top format, countries can perform the exercise individually, or with neighbouring countries, depending upon their strategic national objectives. Current plans call for the exercise to be organised in late 2004 or early 2005, and to take place over a period of a few months. A workshop will then be organised to present, compare and analyse national exercise summary reports, and to draw out common lessons and conclusions.

It is hoped that through these efforts, national planning and preparation for the management of nuclear emergencies will continue to improve to better serve the needs of decision makers, and to allow stakeholder needs and concerns to be addressed in a fashion that builds trust and confidence in government.

P. Pyy, D.F. Ross*

Recurring events: a nuclear safety concern

Nuclear power plant operating experience consists of many types of events with different impacts on safety. Generally, common-cause failures (CCFs) represent the highest risk, since CCFs could make several redundant trains of a safety system inoperable at the same time. Apart from CCFs, the complete or partial repetition of nuclear incidents has also gained attention recently. This phenomenon is called recurrence.

One early example of a recurring event is the Three Mile Island (TMI) accident of March 1979. A similar event had occurred about 18 months before, although with no consequences as the reactor was at low (9%) power. The lessons of the earlier event had not been appreciated. Over the past years, many recurring events have been observed, though fortunately of lesser severity than that of TMI.

What is a recurring event and how is it analysed?

The Working Group on Operating Experience (WGOE) of the NEA Committee on the Safety of Nuclear Installations (CSNI) has produced two reports on recurring events. It also sponsored a workshop on this topic in collaboration with the International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO) in March 2002.

As one result of that work, the following definition has been developed for recurring events:

> *"An event with actual or potential safety significance that is the same or is very similar to important aspects of a previous nuclear industry event(s), and has the same or similar cause(s) as the previous event(s). Additionally, for an event to be considered as recurring, there should exist prior operating experience with corrective actions either:*
>
> *i) identified but not specified, or*
>
> *ii) not adequately specified, or*
>
> *iii) not implemented, or not implemented in a timely manner by the responsible organisation."*

Analysis and evaluation of nuclear operational events have been among the most vital nuclear safety activities for decades. The need to perform this analysis was recently emphasized in the Nuclear Safety Convention (Article 19). Consequently, there are many databases of operating experience for various levels, from plant level disturbances to component data. For instance, the NEA and the IAEA jointly operate the Incident Reporting System (IRS). Industry has, through the World Association of Nuclear Operators (WANO), established another system. Each regulatory body has its own national operating experience system for plant event collection and analysis. In addition, individual utilities, owners groups by reactor type, and reactor vendors have systems tailored to individual needs.

In reflection of the multitude of systems to collect and analyse operating experience, there seems to be no single method for searching for recurring events in a systematic fashion. Hence, the identification of recurring events has been

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done primarily on a case-by-case basis. This observation has warranted WGOE work on improving techniques and methods for the review of operating events.

Examples of recurring events

In the 1990s, in response to a repetition of similar types of events or/and causal factors, NEA member countries decided that a more systematic study of recurrence was required. The first WGOE report[1] identified four examples of recurring events: loss of residual heat removal in PWR mid-loop conditions during outages, BWR instability, service water system clogging and valve pressure locking.

A recurring event of particular interest for pressurised water reactors is the loss of residual heat removal (RHR) cooling while at mid-loop conditions. Some aspects of this scenario are: the primary system is generally open to the containment atmosphere; the main containment may be open; decay heat is being removed by the RHR system; and the steam generators may not be available for RHR. More than 20 occurrences of loss of RHR at mid-loop conditions were observed during the time period 1980-1996, i.e. more than one per year. The events were widely publicised and regulatory bodies made numerous communications. Even so, such events continued to occur.

Another recurring event concerns instability in boiling water reactors. A usual design criterion for BWRs is that either the reactor remains stable by design, or else instabilities are detected and corrected. However, over the period 1982-1995 about ten instances of BWR instability were detected. In some cases, the oscillations were between 40 and 90% neutron power, and the utilities were somewhat surprised when inadvertent instability was experienced.

A third example of recurring events is the reduction or interruption of service water due to buildup of marine life, including clams, barnacles, shrimps and molluscs. Seven such cases were noted over the period 1980-1997. Service water plays an important role in transporting energy from key systems to the ultimate heat sink.

Assessment of recurring events

The results of the first phase of WGOE work showed that there were many reasons to continue this and to involve utilities too. One follow-up action to the first recurring event report was the organisation of an international workshop on this subject, held in March 2002 in co-operation with WANO. This workshop[2] significantly contributed to international knowledge about the causes of recurrence and corrective actions. It also produced invaluable material for the second report[3] on recurring events issued in 2003.

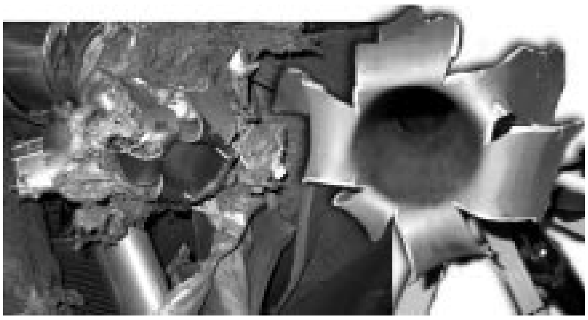
The recurring events identified in the second report are listed in the box. Three recurring events identified in this second report were also identified in the first report. This lends substance to some of the causes of recurring events, notably poor feedback on operating experience.

Examples of recurring events

1. Loss of residual heat removal (RHR) at mid-loop
2. BWR instability
3. PWR vessel head corrosion
4. Hydrogen detonation in BWR piping
5. Steam generator tube rupture
6. Multiple valve failures in the emergency core cooling system (ECCS)
7. Service water system biofouling
8. System level failures due to human factors
9. Strainer clogging

One example of a recurring event newly identified in the second report is PWR corrosion. Two safety-significant recurring events involving degradation of a PWR upper vessel head were reported. Boric acid leaked through cracks in the control rod drive module and attacked the head material. In places, the only remaining control of the primary pressure boundary was the stainless steel cladding. Prior occurrences of corrosion of the upper head or other carbon steel pressure-retaining parts due to boric acid had been reported in a number of member countries, some as far back as 20 years.

As a second example, hydrogen detonations within BWR piping have been reported by several stations. In some cases the immediate consequence was loss of emergency core cooling system (ECCS) train (i.e. the high pressure injection system). The direct cause is the ignition of hydrogen following its separation from oxygen due to the radiolysis of reactor water. In another instance there was unisolable blowdown of steam to the suppression pool. Similar events had been reported as far back as 1985.



Hydrogen explosions in BWR piping have been identified as a recurring event.

Important lessons learnt

The history for some recurring events is up to 20 years. This raises questions as to why corrective actions had not been implemented in a timely manner. Several possibilities exist:

- The operating organisation was not aware of the events or thought that they were not applicable.
- The regulatory authority was not aware of the events or had not imposed timely corrective actions on the licensee.
- Work on the appropriate corrective action was in progress, but not fully implemented.
- The event was considered to be of lesser importance and risk than other plant modifications, and thus was not being pursued as rapidly as needed.
- Overall, the operating experience feedback programme was not fully effective.
- The root cause of the event had not been correctly identified, and thus the corrective actions were not responsive.
- The contributing factors or causes were not appropriately taken into account in identifying the corrective actions.
- What was thought to be a solution was not, or the problem was generic, and what fixed one aspect did not fix all aspects.

It is likely that many if not all of these possibilities play a role in delaying action.

The risk of the recurring events spans a large scale. There is reasonable agreement that the loss of RHR while at mid-loop can be risk-significant, especially if the primary system pressure boundary and/or the containment pressure boundary is open. This was the situation in some cases. In general, making a quantitative risk analysis of recurrence is difficult and may require many assumptions.

There is no rigorous procedure to study reporting systems of operating events that would highlight recurrence. Thus, detection of a recurrent event is largely dependent on the knowledge, memory and expertise of the analyst. One difficulty is that an event may be taking place at several sites internationally, but has not yet recurred within a given country. It is therefore increasingly important for each member country to report all events of safety significance to the IRS system.

Possible avenues for the future

Recurring events are important to safety in that they can indicate deficiencies in the plant safety culture, gaps in the national operating experience feedback systems, loss of continuity in skilled and knowledgeable operations and engineering staff, or lack of attention to design and operational factors such as plant ageing. Due to the fact that national systems may be incapable of detecting recurrence, international activities are required to tackle the problem. The NEA is currently seeking to map effective ways to fight recurrence as part of the CSNI/WGOE programme of work.

One possible remedy for recurrence is wider international dissemination of brief event descriptions extracted from the IRS. Such a description might consist of an abstract; the history of earlier events; direct causes; root causes and contributors; corrective actions; schedule for completion of corrective actions; and safety significance (including risk insights). Circulating this information on a regular basis could prove useful both to the regulatory authorities and to the nuclear utilities.

For minor events, trend analyses may be used to monitor the frequency of component failures or human performance problems, which may indicate weaknesses in plant processes and programmes. Resources to treat this information need to be made available in the plants and the regulatory organisations if the nuclear industry hopes to maintain and further improve its safety and economics. ■

Notes

1. NEA/CSNI/R(1999)19, "Recurring Events", OECD/NEA, Paris.
2. NEA/CSNI/R(2002)25, "Proceedings of the Workshop on How to Prevent Recurring Events More Effectively, 6-8 March 2002, Boettstein, Switzerland", OECD/NEA, Paris.
3. NEA/CSNI/R(2003)13, "Recurring Events", Vol. 2, OECD/NEA, Paris.

Further reading

1. Convention on Nuclear Safety, IAEA, Vienna, June 1994.
2. NEA (2000), *Nuclear Power Plant Operating Experiences from the IAEA/NEA Incident Reporting System, 1996-1999*, OECD/NEA, Paris.
3. IAEA (2003), *Nuclear Power Plant Operating Experiences from the IAEA/NEA Incident Reporting System, 1999-2002*, IAEA, Vienna.

News briefs

Computer-based control systems important to safety (COMPSIS)

Preparations for the launch of a new joint project on Computer-based Control Systems Important to Safety (COMPSIS) have made considerable progress. The proposed project will build on the work of an earlier task force, which collected operating experience in this area and formed a discussion forum to aid regulatory bodies in the licensing of digital instrumentation and control (I&C) systems. It is planned to begin the project during the first half of 2004.

The COMPSIS project aims to facilitate the exchange of operating experience in the area of computer-based control systems important to safety. The overall objective is to improve safety management and the quality of risk analysis of the software used in I&C systems and other equipment. Software and hardware faults in safety-critical systems are typically rare and consequently most countries do not experience enough of them to be able to draw any meaningful conclusions after their occurrence. Combining information from several countries has proved a successful method for overcoming this problem in several other NEA joint projects and this approach will be employed in the course of the COMPSIS project.


Ringhals AB, Sweden

Instrumentation and control (I&C) systems based on computers are vital for the safe operation of nuclear power plants.

A COMPSIS task group was originally formed in 1996. The functions of the task group were to:

1. collect, analyse and report on the operating experience of computer-based systems in nuclear power plants in the participating countries; and
2. evaluate the evolving technology as it is applied to nuclear power plants and identify new issues that might affect the licensing and operation of computer systems in NPPs.

The task group produced a trial database and a set of guidelines issued as NEA/CSNI/R(99)14. The members of the task group concluded at the beginning of 2003 that wider data collection and an in-depth analysis of the issue was worth pursuing internationally. The NEA Committee on the Safety of Nuclear Installations (CSNI) endorsed preparations for a joint project in this area in June 2003.

For further information concerning the COMPSIS project, contact Dr. Pekka PYY (pekka.pyy@oecd.org) of the NEA Nuclear Safety Division.

New publications

Economic and technical aspects of the nuclear fuel cycle

Actinide and Fission Product Partitioning and Transmutation

Seventh Information Exchange Meeting, Jeju, Republic of Korea, 14-16 October 2002

ISBN 92-64-02125-6 – Free on request.

During the last decade interest in partitioning and transmutation (P&T) has grown in many countries around the world. In the years to come, P&T is expected to be one of the key technologies for nuclear waste management, together with geological disposal. In order to provide experts a forum to present and discuss state-of-the-art developments in the P&T field, the OECD Nuclear Energy Agency (NEA) has been holding biennial information exchange meetings on actinide and fission product partitioning and transmutation since 1990. This book and its enclosed CD-ROM contain the proceedings of the 7th Information Exchange Meeting held in Jeju, Republic of Korea, on 14-16 October 2002. The meeting covered the broad spectrum of developments in the field, such as the role of P&T in advanced nuclear fuel cycles; developments in partitioning; developments in accelerators, materials and fuels; the performance of transmutation systems and their safety; R&D needs, including benchmarks, data improvement and experiments; and the role of international collaboration. More than 100 papers were presented during the meeting. These proceedings also contain a summary of the panel discussion on perspectives for the future development of P&T.

Decommissioning Nuclear Power Plants

Policies, Strategies and Costs

ISBN 92-64-10431-3 – Price: € 40, US$ 46, £ 27, ¥ 5 100.

The decommissioning of nuclear power plants is a topic of increasing interest to governments and the industry as many nuclear units approach retirement. It is important in this context to assess decommissioning costs and to ensure that adequate funds are set aside to meet future financial liabilities arising after nuclear power plants are shut down. Furthermore, understanding how national policies and industrial strategies affect those costs is essential for ensuring the overall economic effectiveness of the nuclear energy sector. This report, based upon data provided by 26 countries and analysed by government and industry experts, covers a variety of reactor types and sizes. The findings on decommissioning cost elements and driving factors in their variance will be of interest to analysts and policy makers in the nuclear energy field.

Nuclear Electricity Generation: What Are the External Costs?

ISBN 92-64-02153-1 – Free on request.

Broad economic analysis becomes increasingly important in the context of market deregulation and integration of environmental and social aspects in policy making. External costs will remain a challenge for policy makers as long as they are not assessed and recognised in a reliable and fair way across all sectors of the economy. This report provides insights into the internalised and external costs of nuclear generated electricity and alternative sources. This book will be of interest to policy makers and analysts in the field of energy and electricity systems. It contains authoritative information and data that could assist in their decision-making processes as well as support more in-depth analyses and academic research.

Nuclear regulation and safety

Nuclear Regulatory Review of Licensee Self-assessment (LSA)

ISBN 92-64-02132-9 – Free on request.

Licensee self-assessment (LSA) by nuclear power plant operators is described as all the activities that a licensee performs in order to identify opportunities for improvements. An LSA is part of an organisation's holistic management system, which must include other process elements. Particularly important elements are: a process for choosing which identified potential improvements should be implemented and a process of project management for implementing the improvements chosen. Nuclear regulators expect the licensee to run an effective LSA programme, which reflects the licensee's "priority to safety". Based on contributions from members of the NEA Committee on Nuclear Regulatory Activities (CNRA), this publication provides an overview of the current regulatory philosophy on and approaches to LSA as performed by licensees. The publication's intended audience is primarily nuclear safety regulators, but government authorities, nuclear power plant operators and the general public may also be interested.

Radiation protection

Effluent Release Options from Nuclear Installations

Technical Background and Regulatory Aspects

ISBN 92-64-02146-9 – Free on request.

Radioactive effluent releases from nuclear installations have generally been substantially reduced in recent years, well below regulatory requirements. At the same time, international and intergovernmental agreements and declarations, as well as national policies, continue to seek to optimise and further reduce such releases. Nevertheless, due to societal concerns about levels of radioactivity in the environment, the management of effluent releases from nuclear installations remains high on the agenda of public discussion. This report provides basic technical information on different options for managing and regulating radioactive effluent releases from nuclear installations during normal operation. It should contribute to national and international discussions in this area and be of particular interest to both nuclear regulatory authorities and nuclear power plant operators.

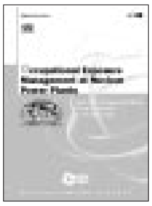
The Future Policy for Radiological Protection

Workshop Proceedings, Lanzarote, Spain, 2-4 April 2003

ISBN 92-64-10570-0 – Price: € 27, US$ 31, £ 19, ¥ 3 700.

The international system of radiological protection is currently being revised with the aim of making it more coherent and concise. The International Commission on Radiological Protection

(ICRP) has published its draft reflections on the system's evolution, and has opened discussions with the radiological protection community in order to seek a broad range of stakeholder input. This open dialogue among stakeholders will help bring about a common level of understanding of the issues at stake and contribute to the evolution of new ICRP recommendations. These proceedings present a significant block of stakeholder input, comprising the views of policy makers, regulators, radiological protection professionals, industry and representatives of both non-governmental and intergovernmental organisations.

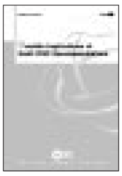


Occupational Exposure Management at Nuclear Power Plants

Third ISOE European Workshop, Portoroz, Slovenia, 17-19 April 2002

ISBN 92-64-02135-3 – Free on request.

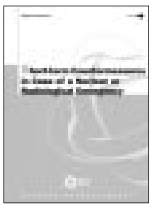
The Information System on Occupational Exposure (ISOE), a joint initiative of the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA), has become a unique worldwide programme on the protection of workers in nuclear power plants, including a network for the exchange of experience in the area of occupational exposure management, and the world's largest database on occupational exposure from nuclear power plants. Each year, an international workshop or symposium offers a forum for radiation protection professionals from the nuclear industry, operating organisations and regulatory authorities to exchange information on practical experience with occupational radiation exposure issues in nuclear power plants. These proceedings include the presentations made at the Third ISOE European Workshop on Occupational Exposure Management at Nuclear Power Plants, held in April 2002 in Portoroz, Slovenia.



Possible Implications of Draft ICRP Recommendations

ISBN 92-64-02131-0 – Free on request.

The Committee on Radiation Protection and Public Health (CRPPH) of the OECD Nuclear Energy Agency (NEA) has, since its inception, worked to develop and improve international norms in the area of radiological protection of the public, workers and the environment. International radiological protection norms continue to evolve, with significant new steps having been taken by the International Radiological Protection Commission (ICRP). Since the issuance of its 1990 recommendations, which form the basis of the international system of radiological protection, the ICRP has continued to add to them. The sum of these recommendations has become overly complicated and at times incoherent. In 1999 the ICRP therefore began to re-evaluate its recommendations with the aim of consolidation, simplification and clarification. New ICRP recommendations are due to be published in 2005. This document, which is supported by the NEA Committee on Radiation Protection and Public Health, and by the NEA Radioactive Waste Management Committee, provides detailed suggestions with regard to the proposed ICRP framework. The stakeholder views expressed in this report have been presented to the ICRP at the second NEA/ICRP Forum in April 2003, and have persuaded the ICRP to reintroduce several key concepts into its proposed new system.



Short-term Countermeasures in Case of a Nuclear or Radiological Emergency

ISBN 92-64-02140-X – Free on request.

Nuclear emergency planning, preparedness and management are essential elements of any country's nuclear power programme. The timely and appropriate implementation of short-term countermeasures can, in case of a nuclear emergency with a release of radioactive material, considerably reduce the doses the public could receive in the vicinity of the nuclear installation.

This report summarises information on national emergency preparedness and planning in NEA member countries for the implementation of short-term countermeasures such as evacuation, sheltering and iodine prophylaxis. The information presented may be used to better understand and to compare existing national approaches, procedures, practices and decisions, which may vary among countries due to different national habits, cultural specificity and societal needs. This report may also assist member countries interested in achieving international harmonisation of short-term countermeasures.

Radioactive waste management

Engineered Barrier Systems (EBS) in the Context of the Entire Safety Case

Workshop Proceedings, Oxford, UK, 25-27 September 2002

ISBN 92-64-10354-6 – Price: € 45, US$ 52, £ 30, ¥ 5 700.

A joint NEA-EC workshop entitled "Engineered Barrier Systems (EBS) in the Context of the Entire Safety Case"was organised in Oxford on 25-27 September 2002 and hosted by United Kingdom Nirex Limited. The main objectives of the workshop were to provide a status report on engineered barrier systems in various national radioactive waste management programmes considering deep geological disposal; to establish the value to member countries of a project on EBS; and to define such a project's scope, timetable and *modus operandi*. This report presents the outcomes of this workshop.

Features, Events and Processes Evaluation Catalogue for Argillaceous Media

ISBN 92-64-02148-5 – Free on request.

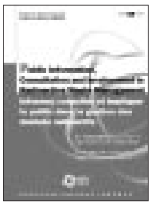
The OECD/NEA Working Group on the Characterisation, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations for the disposal of radioactive waste (known as the "Clay Club") launched a project called FEPCAT (Features, Events and Processes CATalogue for argillaceous media) in late 1998. This report provides the results of work performed by an expert group to develop a FEPs database related to argillaceous formations, whether soft or indurated. It describes the methodology used for the work performed, provides a list of relevant FEPs and summarises the knowledge on each of them. It also provides general conclusions and identifies priorities for future work.

The French R&D Programme on Deep Geological Disposal of Radioactive Waste

An International Peer Review of the "Dossier 2001 Argile"

ISBN 92-64-02136-1 – Free on request.

This report presents the conclusions of the international review team established by the NEA Secretariat at the request of the French government to perform a peer review of the *Dossier 2001 Argile*. The latter was produced by the French National Agency for Radioactive Waste Management (Andra) to describe the research, development and demonstration activities in the French programme on the disposal of high-level and long-lived radioactive waste in a deep geological repository excavated within an argillaceous formation.



Public Confidence in the Management of Radioactive Waste: The Canadian Context

Workshop Proceedings, Ottawa, Canada, 14-18 October 2002

ISBN 92-64-10396-1 – Price: € 45, US$ 52, £ 30, ¥ 5 700.

Public confidence is significantly affected by social considerations, such as public participation in decision-making processes, transparency of activities, access to information, effective and appropriate mitigation measures, development opportunities and social justice issues. In order to increase public confidence, there is a need to fully understand social concerns and to design an effective strategy on how to address them. This is particularly so in relation to radioactive waste management decision making. A workshop held in Ottawa in October 2002 brought together a wide range of Canadian stakeholders to present their views and to debate related issues with delegates from radioactive waste management programmes in 14 countries. This third interactive workshop of the NEA Forum on Stakeholder Confidence focused on key areas such as the social concerns at play in radioactive waste management, how these concerns can be addressed, and development opportunities for local communities. These proceedings provide a summary of the workshop, the full texts of the stakeholder presentations and detailed reports of the workshop discussions.

Public Information, Consultation and Involvement in Radioactive Waste Management

An International Overview of Approaches and Experiences

ISBN 92-64-02128-0 – Bilingual – Free on request.

Institutions involved in radioactive waste management face a rapidly evolving environment stemming from societal changes, including new information technology and new roles for the media. As in many environmental areas, a demand for public participation in decision making creates a need for new approaches to involving stakeholders. This report addresses stakeholder dialogue, consultation and information practices by radioactive waste management institutions at the start of the 21st century. It will provide both the practitioner and the non-specialist with a valuable baseline of detailed, comparative information. It can be used to assess the state of the art in the field as well as to provide a historical perspective when assessing future progress.

The Regulator's Evolving Role and Image in Radioactive Waste Management

Lessons Learnt within the NEA Forum on Stakeholder Confidence

ISBN 92-64-02142-6 – Free on request.

Of all the institutional actors in the field of long-term radioactive waste management (RWM), it is perhaps the regulatory authorities that have restyled their roles most significantly. Modern societal demands on risk governance and the widespread adoption of stepwise decision-making processes have influenced the image and role of regulators. Legal instruments both reflect and encourage a new set of behaviours and a new understanding of how regulators may best serve the public interest. This report, based on the work of the NEA Forum on Stakeholder Confidence, presents findings of relevance to regulators and examines their role within a robust and transparent RWM decision-making process. Detailed international observations are provided on the role of regulatory authorities; characteristics of the regulatory process; attributes that help achieve public confidence; and regulatory communication approaches.

Nuclear law

Nuclear Law Bulletin No. 71

Volume 2003/1

2003 Subscription (2 issues + supplements) – ISSN 0304-341X – Price: € 80, US$ 80, £ 50, ¥ 9 400.

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 subscribers 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, bilateral and international agreements and regulatory activities of international organisations.

Supplement to No. 71: Bulgaria

ISBN 92-64-10378-3 – Price: € 21, US$ 24, £ 14, ¥ 2 700.

Nuclear science and the Data Bank

Benchmark on Beam Interruptions in an Accelerator-driven System

Final Report on Phase I Calculations

ISBN 92-64-02138-8 – Free on request.

In accelerator-driven system (ADS) development, it is important to evaluate temperature variations caused by beam trips as they can result in a temperature transient that would lead to thermal fatigue in the structural components of the subcritical system. A series of benchmarks is therefore being organised by the OECD Nuclear Energy Agency (NEA) for a lead-bismuth-cooled and MOX-fuelled accelerator-driven system. This report provides a comparative analysis of the Phase I calculation results of the beam trip transient benchmark. In subsequent phases of the benchmark, temperature transients in different power densities and under irradiated fuel conditions will also be investigated. This report and those to follow will be of particular interest to ADS designers, including subcritical system physicists as well as accelerator scientists.

Benchmark on Deterministic Transport Calculations Without Spatial Homogenisation

A 2-D/3-D MOX Fuel Assembly Benchmark

ISBN 92-64-02139-6 – Free on request (includes a CD-ROM).

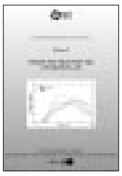
One of the important issues regarding deterministic transport methods for whole core calculations is that homogenised techniques can introduce errors into results. On the other hand, with modern computation abilities, direct whole core heterogeneous calculations are becoming increasingly feasible. This report provides an analysis of the results obtained from a challenging benchmark on deterministic MOX fuel assembly transport calculations without spatial homogenisation. A majority of the participants obtained solutions that were more than acceptable for typical reactor calculations. The report will be of particular interest to reactor physicists and transport code developers.

CINDA 2003

The Index to Literature and Computer Files on Microscopic Neutron Data

ISBN 92-64-02144-2 – ISSN 1011-2545 – Free on request.

CINDA, the Computer Index of Neutron Data, contains bibliographical references to measurements, calculations, reviews and evaluations of neutron cross-sections and other microscopic neutron data; it also includes index references to computer librairies of numerical neutron data available from four regional neutron data centres.The CINDA bibliography allows its users to find the references to specific types of cross-section information or other microscopic data from neutron-induced reactions, for any given target nucleus. In this publication CINDA entries are sorted first by element and mass number and then by cross-section or other quantity. Within these isotopes and quantity groups, the entries are sorted by date of publication.

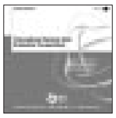


International Evaluation Co-operation

Volume 9: Fission Neutron Spectra of Uranium-235

ISBN 92-64-02134-5 – Free on request.

This report has been prepared by Subgroup 9 which was set up in 1998 with the aim of investigating discrepancies found between microscopic and macroscopic data for the uranium-235 fission neutron spectrum. In addition, it was noted that the most recent evaluation of this spectrum had been performed in 1988 and had been based on only one experiment. It was thus felt necessary to review the existing evaluations, taking into account new experimental data and improved calculations methods.

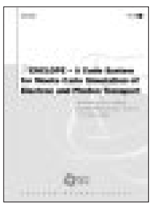


International Nuclear Data Evaluation Co-operation

Complete Collection of Published Reports as of October 2003 (CD-ROM)

Free on request.

The NEA International Nuclear Data Evaluation Co-operation programme brings together evaluation projects being carried out in Japan (JENDL), the United States (ENDF), western Europe (JEFF) and non-OECD countries (BROND, CENDL and FENDL). The Nuclear Data Section of the International Atomic Energy Agency (IAEA) sponsors the participation of evaluation projects from non-OECD countries. The Co-operation programme was established to promote the exchange of information on nuclear data evaluations, measurements, nuclear model calculations, validation, and related topics, and to provide a framework for co-operative activities between the participating projects. The Co-operation programme assesses needs for nuclear data improvements and addresses those needs by initiating joint evaluation and/or measurement efforts. Expert groups are established to solve specific common nuclear data problems. Each expert group produces a final report of its findings. The present CD-ROM contains a full collection of the expert group reports as of October 2003.



PENELOPE 2003 – A Code System for Monte Carlo Simulation of Electron and Photon Transport

Workshop Proceedings, Issy-les-Moulineaux, France, 7-10 June 2003

ISBN 92-64-02145-0 – Free on request.

Radiation is used in many applications of modern technology. Its proper handling requires competent knowledge of the basic physical laws governing its interaction with matter. To ensure its safe use, appropriate tools for predicting radiation fields and doses, as well as pertinent regulations, are required. One area of radiation physics that has received much attention concerns electron-photon transport in matter. PENELOPE is a modern, general-purpose Monte Carlo tool for simulating the transport of electrons and photons, which is applicable for arbitrary materials and in a wide energy range. PENELOPE provides quantitative guidance for many practical situations and techniques, including electron and X-ray spectroscopies, electron microscopy and microanalysis, biophysics, dosimetry, medical diagnostics and radiotherapy, as well as radiation damage and shielding. The proceedings contain the extensively revised teaching notes of the second workshop/training course on PENELOPE held in 2003, along with a detailed description of the improved physics models, numerical algorithms and structure of the code system.

Plutonium Management in the Medium Term

A Review by the OECD/NEA Working Party on the Physics of Plutonium Fuels and Innovative Fuel Cycles (WPPR)

ISBN 92-64-02151-5 – Free on request.

The decision to re-use plutonium generated in thermal reactors is a strategic one for a utility, and is closely tied to its spent fuel management strategy. One option is to reprocess the spent fuel in existing reprocessing plants and immediately re-use the plutonium. Another option is to postpone re-use of the plutonium by placing the irradiated fuel in interim storage. The availability of different types of reactors determines the timescales for the present, medium-term or long-term future re-use of plutonium. Current commercial reprocessing plants are all designed to separate the remaining plutonium at discharge for re-use. Historically, the rationale was to recover sufficient plutonium to enable a build-up of fast reactors, which were expected to be deployed as uranium reserves became scarce and prices rose. For a variety of reasons, but principally that of the low price of uranium ore, fast reactors have not yet been deployed commercially and projected timescales for doing so have been postponed everywhere. This report reviews the technical options available for plutonium management during this interim period. Presenting the consensus views of experts in this field, it is intended to serve as a reference source for researchers as well as utilities.

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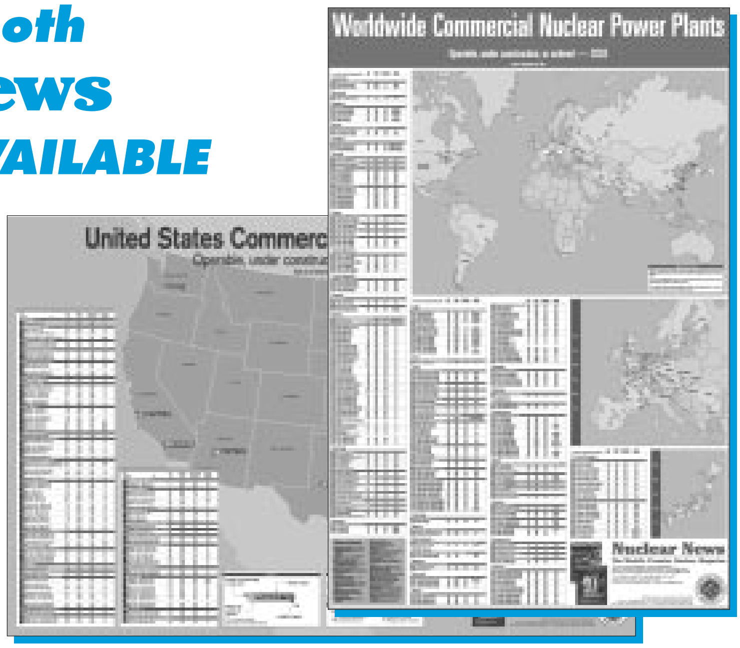

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