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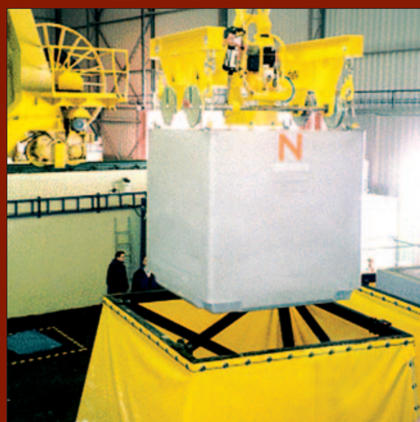
Legislative update: Switzerland



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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, Luxembourg, Mexico, the Netherlands, Norway, Portugal, the Republic of Korea, 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.

For more information about the NEA, see:
www.nea.fr

Cover page: Salamanca uranium mine (Foro Nuclear, Spain); Dounreay laboratory (UKAEA); waste handling at Bohunice NPP (M. Durisova, Slovak Republic); decommissioning at Greifswald (Energiewerke Nord GmbH, Germany); engineers (NEI, USA).

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Nuclear energy: the role of government

In recent times, the environment surrounding the electricity sector has considerably evolved. In many OECD countries, there has been a complete restructuring. New developments include, in some countries, the liberalisation of the electricity market, mergers and acquisitions, an increased role of civil society, energy policy debates, restructuring and reorganisation of government institutions and bodies. The nuclear sector has also been affected by these changes, more so than in other sectors as in the beginning, nuclear facilities were in government hands.

The OECD Nuclear Energy Agency and its member countries have over the last year devoted time and research as well as reflected on the role of government in the nuclear sector in order to assess, in this new environment, what level of involvement is appropriate. Major considerations include security of supply, safety, waste management, research, non-proliferation of radioactive materials and national security considerations. Is there a consensus among countries that apply different economic policies and follow different nuclear strategies? Is there a consensus despite the contrast between market-oriented policies and more government-controlled systems?

On the occasion of the NEA's Steering Committee meeting in April of this year, which coincided with the publication of our study Government and Nuclear Energy, *we had the opportunity to discuss and debate the parameters for what is considered essential to guarantee the continued safe operation of nuclear power plants under liberalised, competitive markets. Clearly, recent experience has shown that the market*

alone cannot dictate policy. Governments have to juggle many interests, but energy policy must be formulated at that level, taking into consideration a full range of factors. Last year, several NEA member countries experienced severe blackouts and electricity shortages. There has been increased debate on the role of the different production means and distribution grids, evaluating the strength and vulnerabilities of each of them. There has also been considerable discussion in many member countries on how to ensure security of supply in the long-term future, whilst caring for the environment and alleviating climate change when projections show continued growth in energy demand.

The debate is not over. However, it is clear to me that we have reached a common understanding on most of the issues at hand. There are, however, different approaches depending on the member country. The exchange of views has certainly helped many in making progress in formulating sound choices.

Luis E. Echávarri
NEA Director-General

Trends in waste arising from nuclear power plants

P. Wilmer*

In the context of policies aiming at sustainable development, minimising the quantity of waste generated is a key goal for any industry. The nuclear energy sector is not unique in generating unwanted material from which society must be protected. Toxic wastes arising from many industries and economic activities represent much larger volumes than radioactive waste from the nuclear energy sector. Indeed, the nuclear industry has been particularly attentive to monitoring, controlling and minimising its waste streams.

In recognition of their responsibility to future generations, governments and the industry have deployed large resources to ensure a safe approach to the management and disposal of radioactive waste. NEA member country governments have implemented comprehensive legal and regulatory frameworks for the safe management and disposal of radioactive waste. In addition, governments are supporting R&D programmes in the field of radioactive waste characterisation, treatment and disposal. They are also involved in the design and implementation of decision-making processes for the siting, licensing and operation of waste repositories adapted to modern governance and the social needs of the twenty-first century.

According to the polluter pays principle, the nuclear industry assumes responsibility for managing the radioactive waste arising from its activities and bears the associated costs. Economic competitiveness, as well as environmental and ethical aspects, has led the operators of nuclear facilities to develop and implement ways and means to reduce the volumes and toxicity of radioactive waste arising and the quantities requiring disposal. Over time, technological progress and improved management have contributed to reduce significantly the amount of waste arising and the volumes to be disposed of per unit of nuclear electricity generated.

The following article focuses on radioactive waste arising from the operation, maintenance and decommissioning of nuclear power plants, which represent the major part of waste from the nuclear industry. It reviews past experience, highlights trends and gives some insights into future prospects for further radioactive waste reduction through improved management and technological progress, including the deployment of advanced evolutionary reactors and eventually of innovative nuclear energy systems of the fourth generation.

Radioactive waste in perspective

Radioactive waste arising from the use of nuclear energy represents small volumes, typically far less than 1% of the overall toxic waste volumes from non-nuclear activities in countries with a nuclear industry.

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In the European Union, for example, around 5 000 m^3 of radioactive waste are produced each year whereas toxic industrial waste volume amounts to some 10 000 000 m^3. The small volumes of radioactive waste are manageable and can be isolated from the biosphere at affordable costs using available technologies. The footprints of the required repositories are very small in geographical terms.

The approach adopted in the nuclear industry for the management of radioactive waste is generally to treat and condition waste materials to ensure their confinement, safe storage and disposal in repositories isolated from the accessible environment. Some other industrial sectors have different approaches to managing their residues, for example by relying on release and dispersion in the environment at concentration levels below authorised thresholds.

Following this conditioning and confinement approach, some types of radioactive waste are already being disposed of in a number of repositories that exist in several OECD countries. The repositories already in operation are designed for the more benign categories of waste. The disposal of other categories has been studied and analysed with practical, tangible projects being developed. Based upon this research and experience at the laboratory level, experts are confident that the management and disposal of all types of radioactive waste can be accomplished satisfactorily (NEA, 1999). However, beyond scientific and engineering issues involved in radioactive waste management, regulatory frameworks and decision-making processes are key factors for the social acceptance of the options selected.

Generally, it is a good technical practice to minimise waste volumes for technical, safety and economic reasons. A well-compacted waste, able to withstand geological pressures, provides stability within a repository and requires less space. However, this logic does not apply to radioactive materials that generate heat as their close proximity may lead to temperatures higher than the maximum at which the integrity of waste packages is sure to be maintained. These two aspects are taken into account in the radioactive waste management approaches being developed and implemented in OECD countries.

Specification of radioactive waste

Radioactive waste is normally classified into a small number of categories, based on the concentration of radioactive material it contains and the time for which it will remain radioactive. Radiation is emitted by radionuclides contained in the waste. The radiation which they emit varies in its fundamental nature, in its energy and with time. Furthermore, they are frequently incorporated in different molecules which behave differently and to which human life and the environment are vulnerable to various extents; radiotoxicity is a measure of this vulnerability.

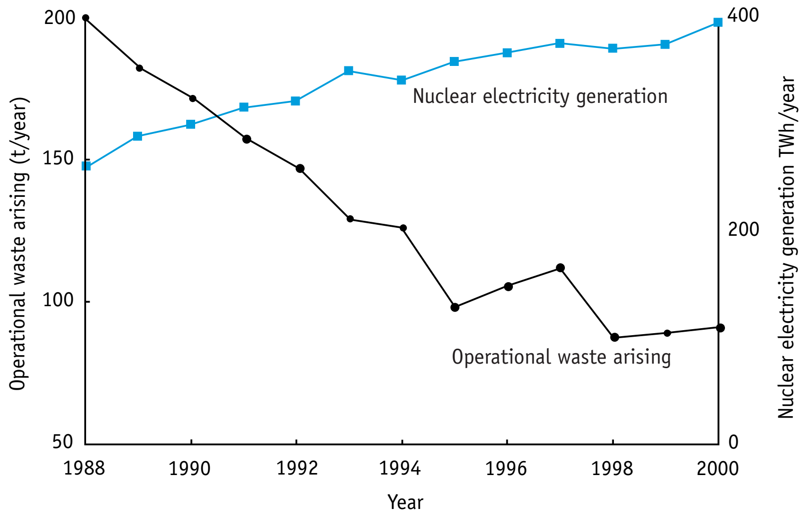
The establishment of a simple, comprehensive, universal categorisation of radioactive waste is challenging and the absence of internationally agreed categories of radioactive waste makes comparisons between countries and assessment of worldwide trends somewhat difficult. However, most countries have established well-defined categories in the national legal and regulatory frameworks which are used for waste management and disposal purposes. In general, the categorisation adopted can be summarised according to three main types: low-level, intermediate-level and high-level waste.

Radioactive material, whether produced by irradiation or contamination in nuclear energy facilities, is invariably associated with non-active materials, such as some form of structure. The quantity of waste to be managed and disposed of depends on the extent to which the radioactivity has been separated from non-active material. The waste manager needs to take account of the benign material as well as of the radioactivity. Also, additional material is often added to raw radioactive waste as part of the process of preparing it for storage and disposal, increasing the volumes to be disposed of but facilitating handling and enhancing safety barriers.

Radioactive waste from plant operation

The operation of nuclear power plants generates radioactive waste, generally in the low-level or medium-level and low-heat waste categories. Because of the cost of operational waste transportation and disposal, and of the need to meet sustainable development policy objectives, operators of nuclear power plants have

Evolution of operational waste quantities and nuclear electricity generation in France



progressively reduced the volume of this type of waste.

Operational waste volumes have been reduced dramatically through improved management practices and the implementation of advanced technologies for waste treatment and packaging. In the United States, the volumes of low-level waste from nuclear facility operation disposed of dropped significantly between 1980 and the early 1990s in spite of the increasing number of nuclear power plants in operation. In France, the same trend has been observed as shown in the Figure, illustrating the evolution of operational waste volumes in the last decade.

Decommissioning waste

The structural material which comprises the nuclear reactor core and its immediate surroundings generally constitutes radioactive waste, mostly low- and intermediate-level waste, when the plant is shut down at the end of its lifetime, decommissioned and dismantled. The volumes are quite large as compared with those arising annually during plant operation; indicatively, it is estimated that future decommissioning waste will represent 80% of the total waste arising from nuclear electricity generation while operational waste represents some 18%.

The mass and volume of the decommissioning waste will remain broadly constant irrespective of the life of the plant. The quantity of radioactive material contained in decommissioning waste increases as plant life proceeds but at a rate reduced relative to time. Plant life extension, a growing practice today, reduces the mass and volume of waste arising per unit of electricity generated.

The opportunity for reducing the quantities of decommissioning waste once plant operation has started is limited in the absence of technological breakthroughs in the field of waste treatment. However, efficient plant operation and management lowers contamination and waste arising to a certain extent.

In the long term, the greatest opportunities for improvement rest with plant designers, and the potential suppliers of new designs of nuclear facilities are very cognisant of the fact. Advanced Generation III+ reactors, such as the evolutionary EPR or the AP1000, are designed for lifetimes of 60 years and to reduce the volume of decommissioning waste to be managed. This will also be the case for Generation IV reactors, which will be based on innovative concepts.

High-level waste and irradiated nuclear fuel

This waste category includes spent fuel discharged from reactors in countries which have chosen the once-through fuel cycle option, and high-level waste from reprocessing in countries which have opted for the closed cycle. Irradiated fuel and high-level waste, although representing only a few per cent of the total radioactive waste volume arising from nuclear energy activities (around 2% for the closed cycle option), is the main focus of attention of the industry, government policy makers and the public. The causes of this attention are the large amount of radioactivity contained in high-level waste, the heat generated by this type of waste and, moreover, the long-term stewardship required to ensure the safe management and disposal of the long-lived radionuclides contained in this waste category.

Regarding spent fuel, technological progress in reactor operation has led to a continuous reduction of volumes per unit of electricity generation. While no significant breakthrough has occurred that would entail a dramatic decrease of spent fuel volumes, significant gains have resulted from higher plant efficiency and enhanced fuel management schemes. The trend of operators worldwide has been to move to fuel element designs and fuel management schemes which increase the energy, and consequently electricity, produced from a given fuel assembly, which itself is largely unchanged in its mass or volume. The reasons for this move have been to reduce the volumes of waste to be transported and stored, to improve economics as well as to lower environmental impacts.

The trend of higher burn-up is illustrated for example by light water reactors (LWRs), which constitute more than 80% of the installed capacity in OECD countries: the average burn-up of discharged LWR fuels increased by some 50% between the early 1960s and the year 2000, reaching now around 45 GWd/tHM or more. The spent fuel volume reductions obtained by increasing burn-ups, however, is accompanied by higher specific radioactivity of the waste destined for disposal.

Actinides produced in nuclear fuel (kg/TWh)

	PWR – N4 type UOx fuel 45 GWd/tHM	PWR – EPR type UOx fuel 60 GWd/tHM	PWR – EPR type 100% MOX fuel 60 GWd/tHM
Plutonium	31.1	26.1	-65.6
Neptunium	1.87	2.02	0.263
Americium	0.628	0.759	4.77
Curium	0.00592	0.0674	3.64
Total actinides	33.8	29.2	-56.9

The composition and radioactivity of irradiated fuel depends on fuel management in the reactor core. As irradiation of fuel increases, the production of those specific radionuclides of critical concern to geological repository designers in the longer term, the so-called long-lived actinides, increases. There have been benefits of the improved fuel utilisation in this regard in terms of the actinides produced by the generation of a unit of electricity but the effect is limited to about 15%. This is illustrated in the Table which presents suppliers' data for the most recent plants commissioned in France (N4) and for the design now under construction in Finland (EPR). (The suppliers' data does not presume the final fuel management schemes chosen by plant owners.)

Reprocessing nuclear fuel to retrieve fissile materials, uranium and plutonium, greatly reduces the volume of heat-generating waste for disposal but gives rise to increased amounts of intermediate-level waste. The recycling of fissile materials also reduces the fresh uranium requirements thereby reducing the waste from uranium mining. For example, with the current or evolutionary generation of light water reactors, recycling uranium and plutonium once in MOX fuel reduces uranium ore requirements by around 10% (NEA, 2002a). Reprocessing followed by recycling also reduces significantly the amounts of plutonium and neptunium sent to HLW repositories (see Table).

Innovative reactors and fuel cycles

Innovative nuclear energy systems are designed for reducing the volumes and radioactivity of waste, in particular through enhanced efficiency or more comprehensive recycling of fissile materials (GIF, 2002). The very high temperature reactor, for example, is aiming at a net thermal efficiency of 50% or more and could achieve average fuel burn-up exceeding 100 GWd/tHM, reducing by a factor of four at least the volume of spent fuel to be disposed of per unit of electricity generated. The sodium-cooled fast reactor is aiming at similar targets in terms of efficiency and burn-up with the additional advantage of a closed fuel cycle eventually resulting in the recovery and recycling of nearly 100% of minor actinides.

In the long term, closed fuel cycles including partitioning and transmutation (P&T) of minor actinides have the potential to achieve a hundred-fold radiotoxicity reduction over a period of more than a century (NEA, 2002b). The design of such schemes, however, still requires large R&D programmes and extensive periods of research and testing to validate the concepts and demonstrate their feasibility before their implementation could be considered. A robust economic assessment of P&T is difficult to conduct at this stage but the benefits of lowering the stewardship burden of future generations would have to be factored into an eventual cost/benefit analysis.

Concluding remarks

The rate at which nuclear waste is accumulated from the generation of electricity has been progressively reduced through technological progress and good facility management practices. Waste volume reductions achieved in the past have been significant regarding operational waste, in particular due to improved plant management and the introduction of advanced conditioning and packaging methods.

The evolutionary reactor designs being built today will continue this trend. Light water reactors achieving higher efficiency and higher burn-up will contribute to reducing the volumes of waste per unit of electricity generated even further. Improved core design and fuel management strategies will also lead to significant gains in terms of minor actinide content of discharged irradiated fuel. Furthermore, the reprocessing and recycling option implemented in some OECD countries contributes to reducing the radiotoxicity of HLW sent to repositories as well as the requirements for fresh uranium.

In the long term, innovative reactors and fuel cycles under consideration or development could greatly reduce specific components of the waste, notably the long-lived minor actinides. However, innovation takes time and such nuclear energy systems are not expected to be ready for deployment before a few decades. Furthermore, fuel cycles involving partitioning and transmutation will require a century or more of operation to bring significant benefits in terms of waste toxicity reduction. In due course, a comprehensive cost/benefit analysis will be required to assess fully the economic, environmental and social dimensions of these innovative options.

Irrespective of potential future improvements, the design and operation of existing and evolutionary nuclear energy systems is oriented towards the management of radioactive waste according to the principles of sustainable development. Evolutionary designs enhance the trend towards minimisation of radioactive waste volumes and toxicity already achieved with the present generation of nuclear power plants.

Radioactive waste should be considered in perspective, in the context of waste and other burdens arising from industrial activities that support economic and social development. The volumes and toxicity of radioactive waste arising from electricity generation are not such that they create an insuperable technical or economic challenge. Societal understanding and acceptance of the implementation of technical solutions that experts find satisfactory remains a challenge. The licensing and commissioning of repositories for all types of waste, in particular HLW, in some member countries will be a major step forward in this regard. ■

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The evolving role of governments in the nuclear energy field

The NEA Nuclear Development Committee (NDC) recently completed a study that looks into the evolving role of governments in nuclear energy matters. Many decisions on government intervention in recent decades have been based on the earlier experience of what works best. The report suggests some considerations that all governments could take into account when establishing their respective roles.

Government and Nuclear Energy [1] looks at the role of governments in the evolving context of the three main goals of energy policy in NEA member countries: adequate and secure supply; competitive markets and prices; and sustainable development, including goals for climate change and air quality. The report examines some of the forces that influence the degree of government intervention, while trying to avoid issues of ideology.

Governments have been deeply involved in the development of nuclear energy. Some of them initiated and led the development of nuclear energy since its military beginnings in World War II, because of its strategic nature and the scope of its risks and benefits. Governments later supported the development of civilian nuclear energy, primarily for the generation of electricity. In the post-war period, governments played an increasing overall role in the economies of the industrial countries. Science and technology were essential instruments of government action and nuclear energy was a highly visible symbol of their successful application.

In the 1980s and 1990s, problems with exclusive government ownership and control of production equipment appeared. Governments came under pressure to cut expenditures and diminish their direct involvement in the economy. Expanding international trade forced all industries to be more competitive. Markets were championed as an alternative to government direction and regulation. Simultaneously, environmental protection and the concept of sustainable development increased in importance in policy making, whilst the need to ensure security of energy supplies persisted or even increased.

In the current era of privatisation and competitive markets, governments still have an essential role in energy, electricity and nuclear energy. While in some countries they may not exercise as much direct control through ownership and economic regulation as in the past, they still have the basic responsibility for creating policy frameworks within which market forces can function and public policy goals can be achieved. So, with fewer direct instruments, governments will need alternative policy measures.

Why governments intervene and when

The reasons for government intervention in nuclear energy have evolved as governments confront their limits. Privatisation and competition mean that many decisions are no longer directly made by governments. However, there will always be strategic reasons for government intervention – national security; emergencies, disasters and health crises; national projects of such importance or urgency that only government can do the job. By and large, the current sentiment in most OECD countries is that the government should intervene only when it is in the best position to carry out the task and when the benefits of intervention outweigh the costs. In fact, the role of governments in nuclear energy varies considerably between countries, according to their specific history and situation.

The economic, social and environmental reasons for government intervention generally fall into two categories: market failure to allocate resources efficiently, and equity or distribution concerns. Market failure may relate to several issues, some of which overlap: public goods, infrastructure, externalities, information and competitive behaviour. However, even if there is a case for government intervention, that intervention itself should be well designed and managed. Both markets and government action can fail, thereby affecting the customers and societies that they serve. The government should have the competence and resources to carry out its interventions effectively.

Actual and recommended involvement

The most important government role is setting overall policy for the economy, energy and the environment, with an adequate base in legislation and institutional competence. In particular, governments should have clear strategies for achieving all three main goals of energy policy over the coming decades. They should show how they will meet climate change and air quality goals, given the current and prospective market dominance of fossil fuels, as well as how to ensure long-term security of supply in open market conditions. In this situation, governments have hard choices to make about whether, when and how to intervene in order to achieve the full range of policy goals.

In privatising and opening markets to competition, governments should make sure that they respect some basic principles. For markets, they have an ongoing responsibility to ensure fairness, access, transparency and effective regulation and to provide the public goods that markets may not otherwise deliver. Governments should ensure security of supply, through incentives or other means guaranteeing that generating and transmission capacity as well as reserve margins are

Electricity sector ownership and concentration

	Private, mixed, or public[2]	Market share of top 3 firms[3]
Belgium	M	96
Canada	M	high*
Czech Republic	PU*	(high)
Finland	M	45
France	PU	92
Germany	PR	64
Hungary	(PU)	(high)
Japan	PR	(high)
Korea	(PU)	(high)
Mexico	(PU)	(high)
Netherlands	M	59
Slovak Republic	(PU)	(high)
Spain	PR	83
Sweden	M	90
Switzerland	PR	(high)
United Kingdom	PR	36
United States	PR	(variable)

* NEA Secretariat estimate.

adequate, and that the grid is effectively regulated to avoid severe fluctuations, or even worse, blackouts.

Governments have a role in looking at the long term to compensate for the high discount rate and short-term perspective of competitive markets, through appropriate tax incentives or other mechanisms. In particular, they should carry out longer-term and fundamental R&D with a sustainable development perspective in mind. They should also assess R&D on the basis of its contribution to achieving the three energy policy goals.

Governments should try as much as possible to treat nuclear energy on a similar basis to other energy sources, while keeping in mind its unique properties. They should sponsor studies that compare the full life-cycle costs and impacts, including risks, across the spectrum of energy sources and uses. They should also internalise the external costs of all energy activities on an even basis. Regulation and liability for radioactive waste should be in line with those for other activities.

Regulation of nuclear safety and security remains a core function of government. It should guarantee the existence of an independent, competent regulator with adequate resources and authority. The emphasis now is on the safety culture of organisations, beginning at the most senior levels. This brings in the need to ensure good governance. Nuclear regulation should be in line with modern regulatory practice across the government, allowing nuclear energy to compete fairly. Governments looking for a future contribution from nuclear energy should ensure that regulation is prepared to deal with issues of decommissioning, refurbishment, uprating, life extension and new reactor designs.

Governments should look beyond regulation to other means of influencing the behaviour of operators and investors. Economic instruments will be important in this regard. Governments will have a role in setting up public processes for the siting and approval of nuclear installations, including waste management facilities.

Governments have a role in ensuring that flexible, stepwise policies are in place for the long-term management of wastes and that funds and institutions are available to carry out the plans. They should oversee the implementation of policy to ensure progress toward waste management goals.

Governments should ensure that the public is adequately informed about energy policy and that there is adequate opportunity for public participation in key energy decisions. Processes for decisions should incorporate the best scientific information as well as a broad spectrum of public views. Governments should take leadership on longer-term energy policy issues and provide clear justification for preferred options. They should also ensure that they and the public can continue to access basic information about energy that may not flow freely in a deregulated regime.

Governments clearly have a lead role in diversion resistance, non-proliferation and national security. This includes responsibility for the physical security of critical infrastructure, including nuclear facilities. Governments should guard against the use of nuclear power materials as radiological weapons. They should also ensure that new fuel cycle and reactor designs have built-in resistance to proliferation from the start.

The international dimension

Intergovernmental co-operation will continue to be essential in the field of nuclear energy. Concerns about nuclear safety and environmental impacts can be effectively addressed through international co-operation and technical assistance. The harmonisation of safety and radiation protection standards is helpful in increasing public understanding, especially in emergency situations. Joint projects on future reactor designs can make efficient use of limited national resources. In addition, international consensus and state-of-the-art reports can contribute to public discussions on nuclear energy. ■

Notes

1. This article is an extract of the Executive Summary of *Government and Nuclear Energy*, ISBN 92-64-01538-8.
2. International Energy Agency (1996), *The Role of IEA Governments in Energy*, OECD, Paris.
3. Commission of the European Communities SEC(2002)1038, *Commission Staff Working Paper: Second Benchmarking Report on the Implementation of the Internal Electricity and Gas Market*, Brussels, Belgium.

Managing and regulating organisational change in nuclear installations

P. Pyy, C. Reiersen*

To the extent that organisational change in nuclear installations can potentially impact nuclear safety, it is imperative to ensure that such change is properly managed and regulated. A number of key elements can help achieve successful management of change.

Nuclear energy companies are, like any organisation, subject to change. They must adapt to meet the different demands which are placed on them as they move through the life cycle from construction and commissioning, through operation, and finally to decommissioning. They are also increasingly required to adapt to a more challenging commercial environment as electricity markets are liberalised.

One of the costs that is often perceived as being amenable to control is staffing, and hence there is significant exploration of new strategies for managing this cost – for example, by reducing staffing levels, changing organisational structures, adopting new shift strategies, introducing new technology or increasing the proportion of work carried out by external contractors. However, if changes to staffing levels or organisational structures and systems are inadequately conceived or executed, they have the potential to affect the way in which safety is managed. Moreover, it may be especially difficult for a utility to recognise and recover from problems arising from changes implemented some time ago. These factors suggest that nuclear regulators may wish to have confidence that utilities are planning and managing change in such a way that it does not compromise nuclear safety.

Need for management of change and structured review processes

Both the utility (licensee) and the regulator should have processes in place to ensure that organisational change is properly managed. The regulator may wish to gain an early and accurate awareness of any proposed organisational change which has the potential to impact nuclear safety. It is useful for the licensee if the regulator's position is stated clearly and applied consistently, thus reducing uncertainty which impairs the licensee's capability to manage its own affairs. The regulator could therefore state formally the process by which organisational changes will be subject to regulatory scrutiny and develop relevant, practical and transparent criteria for assessing organisational change.

The regulator may not wish to examine all of the licensee's proposals for change. This would be time-consuming and would impact adversely on the licensee's

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This article summarises the key findings of the 2001 NEA/CSNI Workshop on the Regulatory Aspects of the Management of Change, which are also captured in the recently published CSNI Technical Opinion Paper No. 5.

management processes. Instead, both regulator and licensee could acknowledge that organisational change can be treated in much the same way as modifications to plant and equipment. The regulator may therefore require the utility to develop a process for managing change which is akin to the process for managing plant modifications. That process could set out the way in which proposals for change are derived, assessed and implemented.

A rigorous process of change would include a number of key elements:

- reference to an organisational "baseline";
- a statement of proposed change;
- categorisation of safety significance;
- an assessment and review of the change proposal in accordance with categorisation;
- an implementation programme and the use of performance indicators;
- a review of change post-implementation.

These elements comprise part of a safety management system or quality system for organisational change management, and as such they should each be subject to periodic review and audit by licensee and regulator. Each of these elements is discussed below.

An example of managing change in the UK

In 1988, the UK government announced that it saw no short-term future for fast reactor technology, and that the UKAEA Dounreay Prototype Fast Reactor would close in 1994. This led to a major rundown in staffing of UKAEA. Between 1988 and 1993, staff numbers fell from 13 600 to 8 300. In 1994, UKAEA split its activities into three business groups, in preparation for the sale of two of these businesses to the private sector. This change of emphasis and the staff reductions significantly reduced UKAEA's technical base, and left it needing to buy a number of services from contractors, including those to whom it had just sold parts of its business. The UK Nuclear Installations Inspectorate (NII) raised concerns about this restructuring and advised UKAEA of its intention to conduct an audit of the management of safety at Dounreay. The audit was postponed to allow UKAEA's new Chief Executive to assess the situation, and for UKAEA to conduct its own review.

Key elements of successful management of change

Firstly, the licensees may be encouraged to analyse and document their current organisational structures and resources. This documentation, which can be regarded as a statement of how the company is able to ensure that nuclear safety is properly managed, can be described as a "baseline assessment". It provides the starting point against which any proposed change to organisational structures and resources can be judged. The change, once implemented, then becomes incorporated as part of the company's updated baseline assessment.

Some regulators may also expect the licensee's baseline assessment to identify vulnerabilities to loss of specific resources, for example where a single person is the principal source of knowledge on certain safety matters, and to identify contingency measures. Confidence that the licensee understands its resource and competence needs, and maintains an effective organisational structure, may be gained from evidence that the licensee has developed performance indicators which monitor safety performance and confirm that nuclear safety functions are being discharged effectively. Such indicators effectively serve to validate the assumptions which underpin the baseline assessment and to identify weaknesses.

The licensee's change process ideally starts with a statement of what the change entails, why it is being introduced and what it is intended to achieve. Clarity of management responsibility is important, and the process should identify who is responsible for proposing, managing and reviewing the change. The programme for introducing the change, and the provisions for subjecting it to peer review, or self-assessment, should be defined. Also the timing of, and interaction with, the regulator should ideally be acknowledged.

Modifications to plant and equipment are categorised in accordance with their nuclear safety significance. Modifications to organisational structures and resources may be treated analogously. The resulting categorisation can then be used to define the scope and quality of

Following up on change

On 7 May 1998, an incident occurred in which a mechanical digger damaged an 11kV electrical cable cutting power supplies to the fuel cycle area of the Dounreay site. According to the NII audit of the management of safety, organisational changes made within UKAEA had so weakened the management and technical base at Dounreay that it was not in a good position to tackle its principal mission, which is the decommissioning of the site. The audit also found that UKAEA was over-dependent on contractors for the delivery of many of the key functions that NII would expect to see under the clear control of UKAEA as the licensee for the site. NII's audit findings[3] resulted in significant changes to the organisation and staffing within UKAEA, with steps being taken to bring many of the key functions back in-house and restore UKAEA's ability to operate as an intelligent customer.

justification. Higher category changes may include a requirement for the change proposal to be subject to regulatory agreement. By adopting such an approach, the licensee and regulator can reach an agreement on those changes that warrant regulatory scrutiny and those where regulatory intervention is not needed, e.g. because regulatory intervention would delay changes that have a positive effect or that have no appreciable safety impact.

Ordinarily, organisational change proposals would be justified by carrying out a level of analysis which is proportionate to the potential impact of the change on nuclear safety. The potential cumulative effects of a series of small changes should also be considered when seeking to ensure an appropriate level of analysis.

It is likely that most proposals for change will try to demonstrate that there remain sufficient competent persons to deliver safety functions, that management responsibilities are clearly defined, and that training needs and procedural modifications have been recognised. However, if it is to offer insight, the analysis also needs to consider the specific risks associated with the change. This will in turn help to identify specific factors which need to be addressed in the justification of a proposal for change.

A programme for implementing the change needs to be developed. The programme should identify those elements of the change which need to be completed in order to enable subsequent stages of the change to proceed (e.g. preparation of revised procedures, training, relocation of staff, etc). A formal project management plan may need to be drawn up to help the management of more complex or extensive changes.

The regulator will gain confidence that the change is suitably controlled if the licensee puts in place indicators to monitor the effects of the change. These indicators should be designed so that they present early warning signals of problems – for example, increased working hours, reduction in "right first time" maintenance, or amount of peer review comment on safety cases.

Finally, the regulator may expect the licensee's change process to specify the conduct of a formal review stage. This will ordinarily be the final stage of each change programme, although for more complex, extensive or significant changes, interim reviews might also be warranted.

What are the other potential pitfalls

Ideally, the utility change management process is clear and visible to the regulator. For instance, it may formally acknowledge the regulator's role, and the timing of its interactions with the licensee. In turn, the regulator should express its own views clearly, and there must be an agreed end-point to the change programme.

The importance of good communication between the regulator and the utility cannot be over-estimated. Dialogue helps to ensure a common perception of the importance of specific issues. Where job changes and personnel redundancy are being planned, licensee staff will be anxious about their job security and the timing of the changes. The regulator may therefore help the licensee ensure that this uncertainty is minimised – for example, by giving the licensee guidance on the type of information that should be included in the change proposal, and by giving clear and early feedback on licensee proposals. However, the regulator must be aware of the impact of its own actions on licensee behaviour, and careful not to constrain unnecessarily the licensee's choice of action or to impose inappropriate demands.

Organisational changes which involve outsourcing roles previously performed by licensee personnel can raise issues which also warrant close regulatory scrutiny. Regulators need to be aware of and assess the licensee approaches to contractorisation. The licensee must always retain its competence and capability to assess the quality of work, and to apply the same standards to contractors as to its own staff, where applicable. The regulator may therefore consider it important that the licensee provides a rigorous demonstration that it retains the ability to act as an intelligent customer.

Furthermore, organisational change, particularly when that change is on a large scale, may have implications for the licensee's ability to maintain an adequate corporate memory – that is, to retain, understand and use intelligently information about the design, operation and maintenance of the plant and, eventually, its decommissioning. The regulator may expect the licensee's change proposals to include a suitable treatment of corporate memory issues. For example, the licensee could show how its succession management arrangements ensure that information and understanding are retained during and following a change. This may include capturing and documenting specific knowledge from experienced personnel, and making arrangements to secure the continued availability of key personnel.

Effective management of factors influencing staff morale, attitudes and motivation is central to the process of managing organisational change. It is reasonable for the regulator to seek confirmation that the licensee is actively considering these factors and taking steps to sustain morale and a positive safety culture. Open and regular communication with staff is likely to be an important feature of the licensee's change management process. Although the regulator may engage in discussion with licensee staff, and may describe the regulatory process which the licensee must follow, it should be mindful of the need to maintain its regulatory detachment and not to undermine licensee management.

The principles set out in this article apply to organisational changes planned by the licensee. It should be recognised that change can also be unplanned – for example, when a person leaves the licensee or when labour is withdrawn because of industrial relations problems. In such circumstances, the regulator would expect the licensee to have arrangements in place for ensuring the delivery of safety functions to cope without application of a formal change management process. If the unplanned event subsequently leads to a decision to change the licensee's organisational structures or its resource or competence requirements, then it would be logical for the licensee's management of change process to apply.

Concluding remarks

Organisational change, if not properly conceived and managed, can affect nuclear safety. The Special Expert Group on Human and Organisational Factors (SEGHOF) of the NEA Committee on the Safety of Nuclear Installations (CSNI) has sought to raise the awareness of licensees and regulators alike by organising meetings and workshops[1] to discuss the issues involved and by producing a Technical Opinion Paper[2]. The SEGHOF continues to carry out work in this area, and the importance of effective management of change throughout the transition from operation to decommissioning will be discussed at the forthcoming international workshop on "Safe, Efficient, and Cost-effective Decommissioning" to be held in Rome, Italy on 6-10 September 2004. ■

Notes

1. NEA/CSNI/R(2002)20, *Workshop on the Regulatory Aspects of the Management of Change – Chester, UK, 10-12 September 2001: Summary and Conclusions*. OECD/NEA, Paris.
2. NEA (2004), *CSNI Technical Opinion Paper No. 5*: *Managing and Regulating Organisational Change in Nuclear Installations*. OECD/NEA, Paris.
3. UK Health & Safety Executive (1998), *Safety Audit of Dounreay*, HSE Books, London.

Further reading

1. INSAG-18 (2003), *Managing Change in the Nuclear Industry: The Effects on Safety. A Report by The International Nuclear Safety Advisory Group*, IAEA, Vienna.
2. IAEA TECDOC 1226 (2001), *Managing Change in Nuclear Utilities*, IAEA, Vienna.

Uranium production and demand: timely mining decisions will be needed

R.R. Price, J.R. Blaise, R.E. Vance*

Uranium resources are abundant. At the beginning of 2003, total known conventional resources (recoverable at <USD 130/kgU) were about 4 590 000 tonnes of uranium (tU). The addition of more speculative resources yet undiscovered but believed to exist based on geological evidence adds about 9 790 000 tU, amounting to total estimated uranium resources of about 14 380 000 tU. Based on the world's reactor-related requirements in 2002 (66 815 tU), these resources are sufficient for several centuries.

However, for a variety of reasons, current production is maintained below demand. In 2002, uranium mine production in 20 countries amounted to about 36 040 tU. The seven leading producing countries, in descending order, were Canada, Australia, Niger, the Russian Federation, Kazakhstan, Namibia and Uzbekistan. Together, these countries provided over 85% of the global output. The two largest producers, Australia and Canada, alone accounted for over 50% of global primary production.

Primary production, therefore, only provided about 54% of world reactor requirements at the end of 2002. The remaining demand was met using secondary sources, such as excess commercial inventories, low-enriched uranium (LEU) derived from highly-enriched uranium (HEU) warheads, re-enrichment of tails and spent fuel reprocessing. In OECD countries the need for secondary sources was even more pronounced since OECD mine production in 2002 (20 114 tU), even accounting for the two largest producers in the world, provided only about 36% of OECD demand (55 490 tU). By the year 2020, reactor-related uranium requirements are projected to rise to between 73 495 tU and 86 070 tU (low and high demand scenarios, respectively).

As currently projected, future primary production capability (including existing, committed, planned and prospective production centres supported by known conventional resources recoverable at a cost of <USD 80/kgU) will not be able to satisfy projected world uranium requirements in either a low or high demand case (see Figure). Primary production capability in 2020 will satisfy only 73-85% of the high and low case requirements. Moreover, these figures can be considered conservative given that production rarely attains 100% of nameplate capacity. Therefore, secondary sources will remain important in meeting world uranium requirements.

However, secondary sources are expected to decline in availability, particularly after 2020, and therefore reactor requirements will have to be increasingly met by primary production. This will thus require the expansion of capacity at existing production centres, the restarting of idled or shutdown production centres, the development of entirely new production centres or the introduction of alternate fuel cycles.

In considering the need for increased primary production and the potential for developing new production centres to provide it, it is necessary to account for the time needed to

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Key dates in the development of selected mines

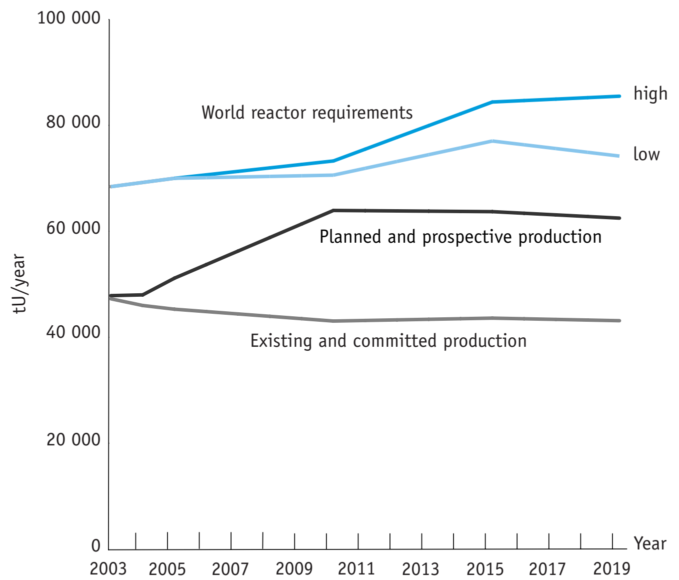
Country	Deposit/ mine	Exploration begins	Discovery of deposit	Beginning of production
Australia	Beverley (ISL)	1968	1970	2000
Australia	Honeymoon (ISL)	1968	1972	not yet announced
Australia	Jabiluka (UG)	1968	1971	not yet announced
Australia	Olympic Dam (UG)	early 1970s	1976	1988
Australia	Ranger (OP)	1968	1969	1981
Brazil	Lagoa Real	1974	1976	2000
Canada	Cigar Lake	1969	1981	not before 2006
Canada	Key Lake	1968	Gaertner: 1975 Deilmann: 1976	Gaertner: 1983 Deilmann: 1989
Canada	McArthur River	1981	1988	1999
Canada	McClean Lake	1974	1979	1999
Kazakhstan	Inkay (ISL)	1976	1979	2001
Kazakhstan	Kanzhugan (ISL)	1972	1974	1982
Kazakhstan	Mynkuduk (ISL)	1973	1975	1987
Kazakhstan	Uvanas	1963	1969	1977
Niger	Akouta	1956	1972	1978
Niger	Arlit	1956	1965	1970

ISL: *in situ* leaching; OP: open pit; UG: underground.

discover and develop new uranium production capability. The lead time for the discovery and development of new uranium production facilities has been of the order of one to two decades (see Table). A variety of factors have contributed to these lag times, such as market conditions, business decisions, environmental assessments and licensing requirements or technical difficulties. Nonetheless, such long lead times could potentially create uranium supply shortfalls, with significant upward pressure on uranium prices as secondary sources are exhausted. The long lead times underscore the importance of making timely decisions to expand production capability well in advance of any projected supply shortfall.

World electricity use is expected to continue growing to meet the needs of an increasing population and economic growth. Nuclear electricity generation is expected to continue to play an important role in the energy mix over the next few decades, at least. It may be called upon to grow considerably. While uranium resources are adequate to meet future projected requirements, a concerted effort will be required to ensure that new resources are developed within the time frame required to meet future demand without shortfalls arising. ■

Annual world uranium production capability through 2020 compared with projected world reactor requirements



Direct indicators for nuclear regulatory efficiency and effectiveness

B. Kaufer, S. Chakraborty*

Since 1998, the OECD/NEA Committee on Nuclear Regulatory Activities (CNRA) has been investigating how to enhance and measure regulatory effectiveness in relation to nuclear installations. In 2002-2003, a pilot project was carried out on 45 potential indicators of regulatory effectiveness, including leading and lagging indicators, and covering both quantitative and qualitative aspects. The results of the pilot project were analysed by a task group and discussed at an international forum on "Measuring, Assessing and Communicating Regulatory Effectiveness" (MACRE 2003).

Regulatory effectiveness and efficiency

Regulatory effectiveness is generally understood as meaning "to do the right work", and regulatory efficiency as "to do the work right". This implies that one has to analyse effectiveness first, based on well-defined mission objectives of the regulatory body. Having done that, one can then work to improve efficiency. Setting goals that are possible to follow-up is very important.

In its 2001 report on *Improving Nuclear Regulatory Effectiveness*, the CNRA provided a distinct definition which stated:

Given the necessary authority and resources as prerequisites, the regulatory body is effective when it:

- *ensures that an acceptable level of safety is being maintained by the regulated operating organisations;*
- *develops and maintains an adequate level of competence;*
- *takes appropriate actions to prevent degradation of safety and to promote safety improvements;*
- *performs its regulatory functions in a timely and cost-effective manner as well as in a manner that ensures the confidence of the operating organisations, the general public and the government; and*
- *strives for continuous improvements in its performance.*

Indicators

Ensuring that nuclear installations are operated and maintained in such a way that public health and safety are protected has been and will continue to be the cornerstone of nuclear regulation. The organisations, structures and processes of regulatory authorities have evolved over the past 50 years. Economic factors, deregulation, technological advancements, government oversight and the general requirements for openness and accountability are some of the elements that have led regulatory bodies to look at their effectiveness. Seeking to enhance the present level of safety by continuously improving the effectiveness of regulatory bodies is seen as one of the ways to strengthen public confidence in the regulatory systems.

The fundamental value of performance indicators for a nuclear regulatory body is to

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focus on its safety mission. Maximum benefit can be derived from the use of performance indicators if they are part of an established quality management model. Performance indicators may also be used to communicate with stakeholders, to monitor internal processes and budgeting, and when necessary to assist strategic development and to manage change. Their use should be part of a continuous improvement process involving all stakeholders, including regulatory staff. Direct indicators are those which measure a regulator's own performance, as distinct from indirect indicators which infer a regulator's effectiveness from its licensee's safety performance.

The direct indicators for the pilot project were developed to be able to:

- verify that regulatory work is performed in accordance with the regulator's mission, strategy and plans;
- verify that work is done according to internal quality procedures and policy;
- measure work performance;
- determine the perception of various stakeholders and staff towards regulatory processes;
- promote the use of detailed work plans for regulatory activities.

Examples of indicators include whether planned inspections or safety assessments had been carried out, or whether the management of contracts had been carried out in accordance with the agreed/published policy.

Results of the pilot project

The pilot project proved the usefulness of direct performance indicators in helping to assess and communicate regulatory efficiency and effectiveness. It also identified potential limits and cautions related to the use of performance indicators, namely that the information provided through the use of indicators completes only part of the overall picture of regulatory effectiveness. The inclusion of many other variables and types of information is required to accurately measure, assess and communicate regulatory effectiveness.

Throughout the pilot project, participants provided feedback regarding their experience in implementing the direct performance indicators, using a template designed for that purpose. The project's task group recognised that, during the course of one year, it was impossible to capture all of the positive and negative aspects of the use of performance indicators. Nevertheless, some of the main observations and conclusions derived in the pilot project showed that the use of direct performance indicators:

- provided a better holistic picture of the work situation and allowed line

NEI, United States.

Duke Power Company, United States.

Taiwan Power Company, Chinese Taipei.

Direct and indirect performance indicators form part of a quality management system.

management to get a better picture of the work situation of every individual;
- allowed the identification of poor performance and triggered corrective actions;
- demonstrated the difficulty of defining indicators that are not influenced by other indicators;
- allowed more effective communication with internal and external stakeholders;
- promoted a better focus on regulatory outcomes;
- should be part of a long-term commitment to self-improvement;
- should be viewed in the context of a balanced quality management system;
- needs to be supplemented with qualitative aspects, indirect indicators and other information in order to get a complete assessment of regulatory performance;
- tends to focus on efficiency rather than effectiveness.

Results from MACRE 2003

A main objective of the forum discussions was to seek verification and validation of the selected measures. Through open panel sessions and small breakout group sessions, participants debated the appropriateness of the indicators chosen, whether others could be applied and what were the most essential measures of a regulator's effectiveness and efficiency. At its conclusion, the forum participants validated the work of the task group and provided helpful insights. Some of the additional conclusions reached at the forum showed that:

- A good regulator brings "added value" to nuclear power plant operators. While this "added value" cannot be measured directly, a comparison with government-owned nuclear facilities exempted from regulation indicates major differences in safety performance.
- Performance indicators are useful: "If you measure it, it will get better."
- Indicators do not measure the actual quality of the work.
- Support was given to external qualitative assessments of a regulator's performance. It is generally accepted that regulatory oversight improves performance of operators; similarly, it was shown that external assessment improves performance of regulators and is commendable.
- The need to improve the regulator's competence was strongly emphasised. Besides technical competence, other important skills are decision making, management and communication.
- A strong consensus was also reached on the importance of public confidence in ensuring regulatory effectiveness.

Future activities

The results of the pilot project and the forum provided clear stimulus for NEA member countries to continue their work in this area. The following recommendations were adopted by the CNRA:

- It is recommended that member countries utilise direct performance indicators, including those presented in *Direct Indicators of Nuclear Regulatory Efficiency and Effectiveness*, to the extent possible to assess and improve their regulatory efficiency and effectiveness. Maximum benefit can be derived from the use of performance indicators if they are part of an established quality management system.
- It is recommended that the CNRA remain active in this area and conduct an annual status review to exchange lessons learnt. A task group should be convened in 2006 to produce a progress report by 2007, taking into consideration other international activities in this area.
- The CNRA should examine methods of integrating all the various efforts and initiatives in the general area of regulatory efficiency and effectiveness.
- It is recommended that the NEA communicate the results of this pilot project to other interested stakeholders (e.g. member and non-member countries).
- It is recommended that the CNRA develop an integrated framework for regulatory efficiency and effectiveness, paying particular attention to qualitative aspects of regulatory performance and the value added by the regulatory body to nuclear safety.

The results of the pilot project were published in early 2004 under the title: *Direct Indicators of Nuclear Regulatory Efficiency and Effectiveness: Pilot Project Results*. The report is available free of charge from the NEA website at www.nea.fr. ■

Geological repositories: political and technical progress

T. Eng*

SKB, Sweden.

High-level decision makers at the conference noted that progress has been made *inter alia* on socio-political issues connected to geological disposal.

The NEA was one of the co-sponsors of the Stockholm international conference on "Geological Repositories: Political and Technical Progress" that was held on 7-10 December 2003. The conference was a follow-up to the Denver international conference on geological repositories held in 1999 on an initiative from the US Secretary of Energy. The Stockholm conference was hosted by the Swedish Nuclear Fuel and Waste Management Company (SKB) and held in co-operation with the International Atomic Energy Agency (IAEA), the European Commission (EC) and the International Association for Environmentally Safe Disposal of Radioactive Materials (EDRAM).

The main objective of the Stockholm conference was to review global progress made since the 1999 Denver conference on activities to develop geological repositories. The conference addressed both policy issues and technical issues and gave an overview of current perspectives in a number of countries. The conference also provided a forum to discuss ongoing efforts and to strengthen international co-operation on waste management and disposal issues. The international conference aimed to bring together high-level decision makers and other interested stakeholders from the national, regional and local levels, as well as regulatory bodies and implementers.

The conference attracted about 210 high-level decision makers from 26 countries. The first day was devoted to policy issues. In the introductory session the IAEA Director-General, Mohamed ElBaradei, and the NEA Director-General, Luis Echávarri, gave their perspectives on geological disposal of radioactive waste and waste management policies. The keynote address was

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given by Claes Ånstrand from the Swedish Ministry for Industry and Trade.

During the two plenary sessions on policy issues presentations were given by people directly involved in the political process through which society deals with its technological challenges. Presenters included high-level representatives from China, the European Commission, Finland, France, Germany, Japan, Sweden and the United States.

The second, more technical day of the conference focused on a set of specific issues associated with repository development. One of the topics discussed was the heightened awareness and need for societal involvement. Also highlighted were the advances made in a number of countries in research, development and demonstration programmes, as well as the importance of safety and security. Further discussions were held on the tools and instruments in place or under development to aid the waste management process.

Key policy messages from the conference

During the policy part of the conference the following key messages were brought forward:

- In undertaking the review of progress in radioactive waste disposal since the 1999 Denver conference, participants confirmed their commitment to the safety and management principles agreed to in such international documents as the IAEA Safety Fundamentals and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management.
- There is international agreement that solutions are required that do not result in undue burden on future generations.
- The international community is adhering to the principle that those who generate the waste should provide for the appropriate management means.
- Disposal in engineered facilities, or repositories, located in suitable formations deep underground, is being widely investigated worldwide as a suitable option.
- Progress is continuously being made on the technological aspects of geological disposal. Although further progress will surely be made, no major breakthrough is expected in this area and many consider the technology to be mature.
- Engineered geological disposal is seen as a radioactive waste management end-point providing security and safety in a sustainable manner. It does not necessarily require long-term monitoring, maintenance and institutional control and is regarded as technically feasible, acceptable from an ethical and environmental viewpoint, and acceptable from an international legal perspective.
- Progress has also been made regarding socio-political issues connected to geological disposal, particularly in the sense that technologists accept that they need help from other, non-technical groups in society.
- Co-operation under the aegis of international organisations such as the IAEA and the NEA is key for developing a broad understanding of important issues at hand and to ensure that options are pursued that have international support.
- All national societies can draw technical help from the common international pool of knowledge, but each one will have to weave it into its national fabric, in its own specific way.

Specific technical and societal issues

During the session on long-term safety and security, it was noted that in 1999, the concept of a long-term "safety case" for disposal facilities had been established in the NEA report on *Confidence in the Long-term Safety of Deep Geological Repositories*. The concept was accepted internationally and further developed thereafter. Since then, a few major safety studies have been finalised and international peer reviews of these studies have been conducted. Since the report was issued in 1999, the aspect of guaranteeing long-term security has also been brought to the fore and is playing an important role in decision making for waste management, including disposal. Some participants stressed that security is an important aspect of the safety issue, rather than a separate issue itself.

The two sessions on stakeholder involvement reflected the heightened attention that stakeholder participation has been receiving over the past few years. Social concerns, public

SKB, Sweden

The Belgian, British and Japanese implementing organisations shared their practical experience of involving stakeholders in the repository siting process.

participation and decision-making processes were reviewed by a number of institutional and non-institutional stakeholders. A broad range of views were brought forward. The first session gave the implementing organisations' perspectives on stakeholder issues, as well as an international, and thus more general, perspective of those issues. Presentations were largely based on work carried out by the NEA Forum on Stakeholder Confidence. The work of the Forum is based on lessons learnt by implementers, regulators, local and regional stakeholders, NGOs, social scientists and others.

The second session on stakeholder involvement highlighted the role of stakeholders responsible for decision making at the municipal level. The session emphasized the experience of siting a final repository for nuclear waste as seen from a community or municipal point of view. The speakers presented an overview of lessons learnt and challenges met, and described what should characterise a good decision-making process in siting a nuclear waste management facility. For example, in addition to providing basic public information on a regular and transparent basis, the waste management authorities and implementers should also be prepared to receive and consider critical research results that are different from their own studies. Indeed, a complete and exhaustive information basis, covering both positive and negative aspects of a project, is seen by stakeholders as a fundamental element in the decision-making process.

During the session on international instruments, presentations were made on the role and implications of various recently adopted international instruments, such as safety requirements and conventions, having a direct or indirect impact on geological repositories and their development. Examples of such instruments are the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, and the Radiation Protection Recommendations as Applied to the Disposal of Long-lived Solid Radioactive Waste. Also discussed was the need to adapt certain long-established international instruments to respond to new technical applications.

When discussing the contribution of research, development and demonstration (RD&D) programmes currently being implemented, it was noted that the knowledge and understanding of processes and phenomena associated with the disposal of radioactive waste in deep geological repositories have made significant progress, partly thanks to *in situ* observations and testing performed in underground research laboratories. The importance of international co-operation in RD&D and its contribution to developing and consolidating the scientific and technical basis for geological disposal was also discussed. International co-operation is especially useful on aspects of research that are not repository-specific, for example thermochemical data. These international efforts complement national efforts under way.

A follow-up conference in this series will probably be held in three to four years, as a joint effort between the IAEA, the NEA and a host organisation. The Stockholm conference proceedings are due to be published by the NEA in the coming months. ■

The regulatory application of authorisation in radiological protection

T. Lazo, S. Frullani *

Authorisation is the process used by governments and regulatory authorities to decide what regulatory controls or conditions, if any, should be applied to radioactive sources or radiation exposure situations in order to protect the public, workers and the environment appropriately. Over the years, governments and regulatory authorities have used various approaches to the authorisation process under differing circumstances. Now, with the new draft recommendations from the International Commission on Radiological Protection (ICRP), there is the prospect of being able to use a single, simple and self-coherent approach for the process of regulatory authorisation under all circumstances.

Previously, the ICRP recommended the use of various approaches to manage radiological protection situations. For what were called *practices*, exposures were subject to *limits*, and *optimisation* was required below these limits. What were called *interventions* were subject to *intervention levels*, above which some action could be considered *justified*, and which should be *optimised* based on consideration of how much dose could be averted by the countermeasure considered. Radon in homes was subject to *action levels*, above which some sort of countermeasure could be recommended. These approaches are all philosophically distinct and logically constructed, but their differences, particularly in the types of numerical criteria used (limits, intervention levels, action levels, etc.) contributed to confusion and misunderstanding.

A new approach to the regulatory process of authorisation

The process proposed by the NEA Committee on Radiation Protection and Public Health (CRPPH) is based on the new draft ICRP approach of using *optimisation* below a *dose constraint* for all cases. As such, the process of regulatory authorisation begins by treating all radiation sources and exposure situations equally. All sources (i.e. cosmic, terrestrial, natural, artificial) and exposure situations (i.e. planned, accidental, de facto) are then considered, characterised and screened. Situations covered include:

- what the ICRP previously referred to as *practices* and *interventions*;
- all exposures to natural radioactivity, e.g. radon,

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naturally occurring radioactive materials (NORM), and cosmic ray exposure in air travel;

- public, worker and environmental exposures;
- prolonged exposures.

Based on this characterisation and screening, some sources and exposure situations will clearly not be amenable to dose reduction through regulatory controls and would thus not be subject to any regulatory controls (i.e. cosmic rays at the earth's surface). Some sources and exposure situations will not be socially justified and will not be allowed (i.e. the deliberate use of radioactive material in toys). Most sources and exposure situations will require further analysis before a regulatory decision regarding any necessary protection actions can be made. Regulatory analysis of these cases will include the optimisation of protection using an individual dose constraint as the upper bound. Regulatory controls will be imposed based on, among other considerations, the level of residual dose remaining after protection has been optimised.

A. Gonin, CEA, France.

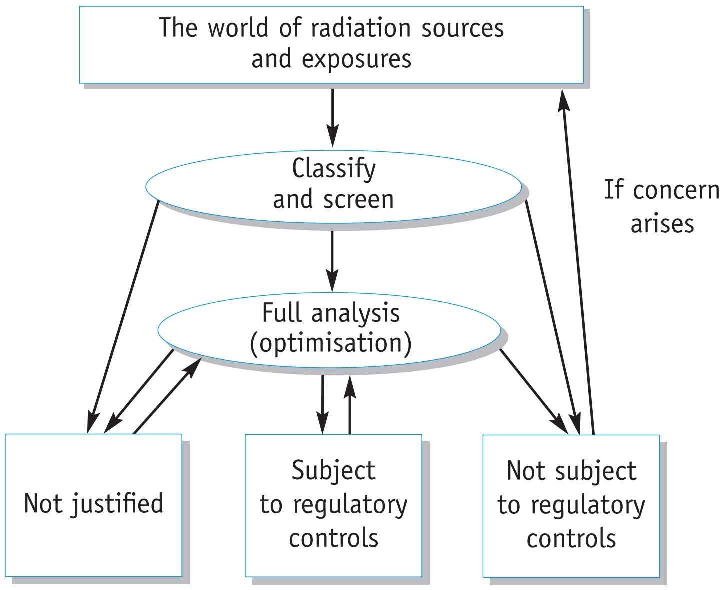
Monitoring contamination levels as part of optimisation of public and worker protection.

In addition to this review of "new" sources and exposure situations, previous government or regulatory decisions may, from time to time, be revisited, motivated by changing technology and/or social norms. This could be the case for sources and exposure situations that have previously been declared unjustified, or for those for which protection measures have previously been optimised and regulatory controls imposed. This re-evaluation could lead to a new view of whether the source or exposure situation is or is not justified, or could result in a change in regulatory controls.

Finally, for some sources and exposure situations deemed to be justified, the optimum protection will be not to require regulatory controls. For these situations, the exposures will be allowed without regulatory control of the user, and the materials will be allowed to be freely released. This will be the case, for example, for the use of traces of natural radioactive material in consumer devices (i.e. tritium in emergency exit signs or watches, thorium in welding rods), for the discharge of liquids and gases containing small concentrations of natural or artificial radionuclides (i.e. from nuclear power plants, hospitals or research institutions), or for the release of solid or liquid materials containing small concentrations of natural or artificial radionuclides (i.e. tools from within contaminated areas, or in some countries, rubble from decommissioning activities). These materials will generally be regulated up to their point of release, and regulators may require such things as environmental measurements and dose modelling. While governments and regulatory authorities will not try to "regain control" over these released materials, their existence may be considered when making future regulatory decisions regarding other sources and exposure situations that may expose the affected population to additional doses.

Throughout this process, stakeholder involvement is essential. This does not mean that a large, public consultation process needs to be initiated for every government decision regarding radiological protection. However, the acceptability of a decision is a subjective,

The regulatory process of authorisation



relative concept, and as such the relevant stakeholders for any particular situation will need to be consulted so that the final decision will enjoy the acceptance of those affected. In many cases, the relevant stakeholder group will simply be the regulatory authorities and the licensee, while in others, broader consultation of the public may be necessary.

Motivation for change: simplicity, coherence, transparency

The value and innovation of this new approach comes primarily from two aspects. First, all sources and exposure situations are treated in the same fashion, using optimisation below a predetermined dose constraint. This results in a system that is simple, consistent and coherent. It avoids the need to explain and justify, as previously necessary, why some regulatory "levels" were not to be passed (limits), and others required no actions until they were passed (action levels, intervention levels). This single approach can be more easily and transparently applied, and by addressing all situations equally it portrays a positive, proactive image of the government and regulatory authorities.

Second, this approach has tried to avoid the use of terminology that in the past has been confusing, such as *exclusion*, *exemption* and *clearance*. By concentrating only on the procedural aspects of radiological protection decision making, this approach emphasizes the reasoning behind decision pathways rather than specific and narrowly defined concepts. This again simplifies the approach.

Steps in the authorisation process

Conceptually, the authorisation process can be thought of as a series of analytical assessments leading to decision points. Decisions are made based on various criteria, and result in the identification of any regulatory actions warranted for the radioactive material, radiation exposure, or radiation exposure situation in the context being considered. This process can be iterative, and can be as detailed or as schematic as necessary depending upon the risks being considered.

All radiation sources and exposure situations are subject to analysis by the regulatory authorities. For those sources analysed, the regulatory authority will perform a preliminary process to *characterise and screen* each source or exposure situation. The characterisation of the source or exposure situation is made in order to decide whether further analysis is necessary, or whether a clear choice is possible immediately. The screening of the source or exposure situation is to allow the regulatory authority to make a decision regarding regulatory control.

For some cases, the regulatory authority will perform further analysis or *optimisation*. The focus of optimisation is on the protective actions that can be applied to reduce exposures. These actions can be applied to the exposure (i.e. actions applied directly to the individual being exposed, or actions applied along the pathway of exposure), or to the source of the exposure (i.e. shielding at the source, reduction of emission, etc.). The desired result of optimisation is that the exposures remaining after the implementation of protective actions are as *low as reasonably achievable* (ALARA). As a result of this optimisation process, there are several possible decisions that can be made regarding the sources or exposure situations under consideration. This could include deciding that a particular exposure situation is no longer justified, or on the contrary that a previously unjustified situation can now be justified.

Following analysis, some sources and exposure situations will be subject to regulatory conditions. A graded approach will be taken. For small sources or low-dose situations with no significant chance for a high-exposure accident, simple notification from the "operator" to the regulatory authority may be sufficient. For sources or exposure situations with higher radiological risks, more stringent controls may be necessary, including formal review and licensing processes, requirements for environmental modelling and measurement, requirements for individual dosimetric assessment and/or measurement.

As a result of this process, there will be some sources and exposure situations that are not subject to regulatory controls. Examples of such situations may vary from country to country, but may include natural radioactivity in food and drinking water, solid material that has been released from decommissioning processes, and smoke detectors or other devices with radioactivity. Once authorised, it will generally not be possible for regulatory controls to directly affect these sources and exposure situations. However, this does not mean that the regulatory authority will forget that these exposures exist. In making future decisions, such as those which may cause exposure to populations already affected by released materials, the regulatory authority may consider the existence of those sources that have already been released with no regulatory conditions.

In the end, certain sources and exposure situations will not be subject to regulatory control and will not, in general, be re-evaluated. However, should radionuclides that have been released in solid, liquid or gaseous form be "rediscovered" and be drawn to the attention of regulatory authorities, there may be a need to characterise and screen such situations.

Conclusions

Since the development of new ICRP recommendations began, it has been clear that the need to change is not driven by new scientific knowledge about risks, but rather by the need to simplify, rationalise and consolidate the Commission's recommendations. To this end, the CRPPH is proposing the use of a single regulatory process to interpret and implement the ICRP's recommendations for all radiological protection situations. The CRPPH feels that this will not only simplify the work of governments and regulatory authorities, but will result in a system of radiological protection that is easier to implement and explain, and that will thus be more accepted and sustainable. ■

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3. NEA (2000), *A Critical Review of the System of Radiation Protection: First Reflections of the OECD Nuclear Energy Agency's Committee on Radiation Protection and Public Health*, OECD/NEA, Paris.

News briefs

Legislative update: Switzerland

On 21 March 2003, the Swiss Federal Assembly adopted the new Act on Nuclear Energy[1]. This is the culmination of a long process which began in the 1970s, the revision work having been interrupted on several occasions. The new Act repeals the Atomic Energy Act of 23 December 1959 and the Federal Order of 6 October 1978 pursuant to it, which have until now served as the framework for the use of nuclear energy in Switzerland. Two constitutional initiatives for abandoning nuclear energy - "Moratoire plus" and "Sortir du nucléaire" - were put to the popular vote on 18 May 2003. The first concerned the prolongation of the moratorium on the construction of nuclear power plants, whereas the second proposed the gradual decommissioning of existing plants. Both initiatives were rejected.

The new Act, which has not been subject to a referendum, lays down the conditions for the safe operation of nuclear installations, strengthens public participation in decision-making and includes, *inter alia*, guidelines for nuclear waste management. The main provisions of the new Act are as follows:

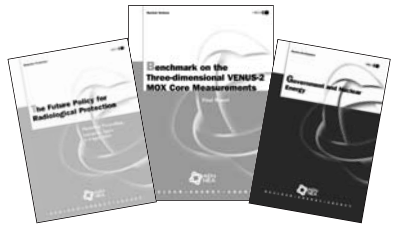
- Nuclear energy will continue to be used in Switzerland, since the new Act provides that nuclear power plants may still be constructed as long as the most advanced technology is used. Furthermore, licences to operate nuclear power plants are not limited in time.
- All new nuclear installations (nuclear power plants or underground radioactive waste repositories) require a general licence. The canton in which the installation is to be located, as well as the cantons and States in close proximity to the planned installation, will be involved in preparing the general licence, although the agreement of the canton in which the installation is to be located is not necessary. The general licence will be issued by the Parliament, and will be subject to an optional referendum.
- A moratorium will be introduced for the reprocessing of nuclear waste. The Act specifies that spent nuclear fuel may not be exported for reprocessing for a period of ten years, starting 1 July 2006. During this period, spent nuclear fuel will have to be disposed of as radioactive waste. The moratorium may be extended for a further ten years by the Federal Assembly, which refused to impose an immediate ban on the reprocessing of radioactive waste. Radioactive waste disposal is moreover based on a new concept formulated by a Group of experts. Waste must be placed in a deep geological repository which remains under surveillance, with a guarantee that the waste can be easily recovered. Once sealed, the repository will become the responsibility of the Confederation.
- Lastly, a decommissioning fund is to ensure the financing of the decommissioning and dismantling of nuclear installations withdrawn from service, while a second fund will ensure the financing of the disposal of radioactive waste. These funds are designed to guarantee that after 40 years of operation of a nuclear installation, monies are available to finance decommissioning and radioactive waste disposal.

The Act is due to enter into force in January 2005, following the completion of important legislative work that remains. The entry into force of the Act is subject to the adoption of a new Nuclear Energy Order (implementing Order), which should be approved by the Federal Council towards the end of the year 2004. Furthermore, existing Orders (notably concerning radiation protection) are to be amended. ■

Note

1. The text of this Act is contained in the Supplement to *Nuclear Law Bulletin* No. 72.

New publications



Economic and technical aspects of the nuclear fuel cycle

Government and Nuclear Energy

ISBN 92-64-01538-8 – Price: € 21, US$ 26, £ 15, ¥ 2 700

The main objective of national energy policies in OECD countries is to ensure the availability of secure and economic supplies with minimal environmental impact. The means of achieving security and competitiveness in the supply of electricity differ between countries. Some governments resort to competitive markets while others maintain ownership and apply strict economic regulation. Environmental goals are pursued by direct regulation and sometimes, for example in the case of carbon dioxide emissions from power plants, by adopting market-based approaches. This publication addresses the roles and responsibilities of governments in the field of nuclear energy, within the context of broad national policy goals, and reviews the tools available to achieve those goals. It will be of particular interest to decision makers in government and the industry, as well as to energy policy analysts and journalists.

Nuclear Energy Data – 2004

Bilingual – ISBN 92-64-01632-5

Price: € 21, US$ 26, £ 15, ¥ 2 700.

This new edition of *Nuclear Energy Data,* the OECD Nuclear Energy Agency's annual compilation of essential statistics on nuclear energy in OECD countries, offers additional graphical information as compared with previous editions allowing a rapid comparison between capacity and requirements in the various phases of the nuclear fuel cycle. It provides the reader with a comprehensive but easy-to-access overview on the status of and trends in the nuclear power and fuel cycle sector. This publication is an authoritative information source of interest to policy makers, experts and academics involved in the nuclear energy field.

Uranium 2003: Resources, Production and Demand

A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency

ISBN 92-64-01673-2 – Price: € 85, US$ 106, £ 59, ¥ 10 900.

The "Red Book", jointly prepared by the OECD Nuclear Energy Agency and the International Atomic Energy Agency, is a recognised world reference on uranium. This edition, the 20th, presents the results of a thorough review of world uranium supplies and demands as of 1 January 2003 based on official information received from 43 countries. It paints a statistical profile of the world uranium industry in the areas of exploration, resource estimates, production and reactor-related requirements. It provides substantial new information from all major uranium production centres in Africa, Australia, Eastern Europe and North America and for the first time, a report for Turkmenistan. Also included are international expert analyses and projections of nuclear generating capacity and reactor-related uranium requirements through 2020. The long lead times required to bring resources into production underscores the importance of making timely decisions to pursue production capability well in advance of any supply shortfall.

Nuclear regulation and safety

Collective Statement Concerning Nuclear Safety Research

Capabilities and Expertise in Support of Efficient and Effective Regulation of Nuclear Power Plants

ISBN 92-64-02169-8 – Free: paper or web.

This statement articulates the value to efficient and effective regulation, as well as to safety, of maintaining safety research capability and expertise. It can serve as a guideline for consideration by NEA member countries in determining what safety research capability and expertise should be maintained in support of regulation and why.

Collective Statement Concerning Nuclear Safety Research

Good Practice and Closure Criteria

ISBN 92-64-02149-3 – Free: paper or web.

The method for setting nuclear safety research priorities and the criteria for ranking programmes and projects, including for their closure, vary from one country to another. This collective statement addresses good practices in conducting nuclear safety research and focuses on closure considerations. It also considers the effects that closure can have for regulators and the industry, including potential losses of technical capability, expertise and facilities.

Direct Indicators of Nuclear Regulatory Efficiency and Effectiveness

Pilot Project Results

ISBN 92-64-02061-6 – Free: paper or web.

The desired outcome of nuclear regulatory activities is the safe operation of nuclear facilities in a manner that protects public health and safety, and the environment. The operator has prime responsibility for safe operation; however, the actions of the regulator contribute to this objective. A task group was established by the NEA Committee on Nuclear Regulatory Activities (CNRA) to develop a set of direct performance indicators of regulatory efficiency and effectiveness. This report describes the pilot project carried out by the task group to test the indicators developed, and makes some general observations about the usefulness of individual indicators as well as recommendations for future activities.

CSNI Technical Opinion Papers

No. 3: Recurring Events

ISBN 92-64-02155-8 – Free: paper or web.

Feedback on operating experience from nuclear power plants is intended to help avoid occurrence or recurrence of safety-significant events. Well-established feedback systems exist on the national and international levels. This technical opinion paper presents the international systems used to collect operating experience, the role of recurring events within them, examples of recurrence and ideas about how to improve the situation.

CSNI Technical Opinion Papers

No. 4: Human Reliability Analysis in Probabilistic Safety Assessment for Nuclear Power Plants

ISBN 92-64-02157-4 – Free: paper or web.

This technical opinion paper represents the consensus of risk analysts in NEA member countries on the current state of the art of human reliability analysis (HRA) in probabilistic safety assessment (PSA) for nuclear power plants. The paper's objective is to present decision makers in the nuclear field with a clear technical opinion on HRA status as implemented in industrial PSAs.

CSNI Technical Opinion Papers

No. 5: Managing and Regulating Organisational Change in Nuclear Installations

ISBN 92-64-02069-1 – Free: paper or web.

If changes to staffing levels or organisational structures and systems are inadequately conceived or executed they have the potential to affect the way in which safety is managed. In this context, the NEA Committee on the Safety of Nuclear Installations (CSNI) and its Special Expert Group on Human and Organisational Factors (SEGHOF) organised an international workshop to discuss the management and regulation of organisational change. This technical opinion paper distils the findings of that workshop and sets out the factors that regulatory bodies might reasonably expect to be addressed within licensees' arrangements to manage organisational change.

Radiological protection

Evolution of the System of Radiological Protection

Asian Regional Conference, Tokyo, Japan, 24-25 October 2002

ISBN 92-64-02163-9 – Free: paper or web.

The development of new radiological protection recommendations by the International Commission on Radiological Protection (ICRP) continues to be a strategically important undertaking, both nationally and internationally. With the growing recognition of the importance of stakeholder aspects in radiological protection decision making, regional and cultural aspects have also emerged as having potentially significant influence on how protection of the public, workers and the environment are viewed. Differing cultural aspects should therefore be considered by the ICRP in its development of new recommendations. Based on this assumption, the NEA organised the Asian Regional Conference on the Evolution of the System of Radiological Protection to express and explore views from the Far East. Held in Tokyo on 24-25 October 2002, the conference included presentations by the ICRP Chair as well as by radiological protection experts from Japan, the Republic of Korea, China and Australia. The distinct views and needs of these countries were discussed in the context of their regional and cultural heritages. These views, along with a summary of the conference results, are presented in these proceedings.

The Future Policy for Radiological Protection

A Stakeholder Dialogue on the Implications of the ICRP Proposals – Summary Report, Lanzarote, Spain, 2-4 April 2003

ISBN 92-64-02165-5 – Free: paper or web.

At the end of the 1990s, the International Commission on Radiological Protection (ICRP) launched a process for establishing new recommendations, which are expected to serve as guidelines for national systems of radiological protection. Currently the ICRP's proposed recommendations are being subjected to extensive stakeholder comment and modifications. The NEA Committee on Radiation Protection and Public Health (CRPPH) has been actively involved in this process. Part of the Committee's work has been to undertake collaborative efforts with the ICRP through, for example, the organisation of broad stakeholder fora. The first of these, held in Taormina, Italy in 2002, focused on the development of a policy basis for the radiological protection of the environment. The second forum, held in Lanzarote, Spain in April 2003, addressed the latest concepts and approaches in the ICRP proposed recommendations for a system of radiological protection. During this meeting, the ICRP listened to the views of various stakeholder groups, including radiological protection regulators, environmental protection ministries, the nuclear power industry and NGOs. As a result, the ICRP modified its proposals to better reflect stakeholder needs and wishes. This report presents the outcomes of the discussions, examining what the ICRP proposed and how its proposals have been affected and modified as a result of stakeholder input.

Occupational Exposures at Nuclear Power Plants

Twelfth Annual Report of the ISOE Programme, 2002

ISBN 92-64-02164-7 – Free: paper or web.

The Information System on Occupational Exposure (ISOE) was created by the OECD Nuclear Energy Agency in 1992 to promote and co-ordinate international co-operative undertakings in the area of worker protection at nuclear power plants. The ISOE Programme provides experts in occupational radiation protection with a forum for communication and exchange of experience. The ISOE databases enable the analysis of occupational exposure data from the 465 commercial nuclear power plants participating in the Programme (representing some 90 per cent of the world's total operating commercial reactors). The Twelfth Annual Report of the ISOE Programme summarises achievements made during 2002 and compares annual occupational exposure data. Principal developments in ISOE participating countries are also described.

Radioactive waste management

The Handling of Timescales in Assessing Post-closure Safety

Lessons Learnt from the April 2002 Workshop in Paris, France

ISBN 92-64-02161-2 – Free: paper or web.

A workshop entitled "The Handling of Timescales in Assessing Post-closure Safety" of deep geological repositories for radioactive waste was organised by the NEA in April 2002. This report presents the main lessons learnt from the workshop discussions and is intended to help promote the better understanding of issues related to the handling of timescales in a safety case.

The Regulatory Control of Radioactive Waste Management

Overview of 15 NEA Member Countries

ISBN 92-64-10650-2 – Price: € 50, US$ 63, £ 35, ¥ 6 400.

Regulators are major stakeholders in the decision-making process for radioactive waste management. The NEA Radioactive Waste Management Committee (RWMC) has recognised the value of exchanging and comparing information about national regulatory practices and having an informal, international network for discussing issues of common concern. The RWMC Regulators' Forum provides considerable opportunity for such activities. This report presents the initial results of the Forum's work. Information is given for 15 NEA member countries in a format that allows easy accessibility to specific aspects and comparison between different countries. It includes an array of facts about national policies for radioactive waste management, institutional frameworks, legislative and regulatory frameworks, available guidance, classification and sources of waste and the status of waste management. It also provides an overview of current issues being addressed and related R&D programmes.

Safety of Disposal of Spent Fuel, HLW and Long-lived ILW in Switzerland

An international peer review of the post-closure radiological safety assessment for disposal in the Opalinus Clay of the Zürcher Weinland

ISBN 92-64-02063-2 – Free: paper or web.

Studies are under way in Switzerland to investigate various aspects of the geological disposal of radioactive waste. This report presents the results of the international peer review organised by the OECD Nuclear Energy Agency (NEA) on behalf of the Swiss Federal Office of Energy (BFE) of a post-closure radiological safety assessment prepared by Nagra for geological disposal of spent fuel (SF), vitrified high-level waste (HLW) and long-lived intermediate-level waste (ILW) within the Opalinus Clay of the Zürcher Weinland in northern Switzerland.

Also available in German:

Die Sicherheit der geologischen Tiefenlagerung von BE, HAA und LMA in der Schweiz

Eine internationale Expertenprüfung der radiologischen Langzeitsicherheitsanalyse der Tiefenlagerung im Opalinuston des Zürcher Weinlands

Nuclear law

Nuclear Legislation in Central and Eastern Europe and the NIS

2003 Overview

ISBN 92-64-01542-6 – Price: € 48, US$ 60, £ 33, ¥ 6 100.

This publication examines the legislation and regulations governing the peaceful uses of nuclear energy in eastern European countries. It covers 11 countries from Central and Eastern Europe and 12 countries from the New Independent States: Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Former Yugoslav Republic of Macedonia, Georgia, Hungary, Kazakhstan, Latvia, Lithuania, Poland, Republic of Moldova, Romania, Russian Federation, Slovak Republic, Slovenia, Ukraine, Uzbekistan. The chapters follow a systematic format making it easier for the reader to carry out research and compare information.

Nuclear Law Bulletin No. 72

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

Considered to be the standard reference work for professionals and academics in the field of nuclear law, the *Nuclear Law Bulletin* is 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 adminisrative decisions, bilateral and international agreements and regulatory activities of international organisations.

+ Supplement to No. 72: Switzerland

ISBN 92-64-01985-5 – Price: € 21, US$ 24, £ 14, ¥ 2 700.

Nuclear science and the Data Bank

Benchmark on the Three-dimensional VENUS-2 MOX Core Measurements

Final Report

ISBN 92-64-02160-4 – Free: paper or web.

In order to validate the calculation methods and nuclear data used for the prediction of power in MOX-fuelled systems, the OECD Nuclear Energy Agency (NEA) has examined a series of theoretical physics benchmarks and multiple recycling issues of various MOX-fuelled systems. This has led to many improvements and clarifications in nuclear data libraries and calculation methods. The final validation requires linking those findings to data from experiments. Hence, the first experiment-based benchmarks using the VENUS-2 MOX core measurement data were undertaken in 1999. The two-dimensional benchmark was completed in 2000. A full three-dimensional benchmark using 3-D VENUS-2 MOX core experimental data was launched in 2001 for a more thorough investigation of the calculation methods. This report provides details of the comparative analysis of the 3-D calculation results against experimental data. Results obtained with the latest nuclear data libraries and various modern 3-D calculation methods are analysed. The report will be of particular interest to reactor physicists and nuclear engineers as well as to nuclear data evaluators.

Chemical Thermodynamics of Americium

Reprint of the 1995 Review

ISBN 92-64-02168-X – Free: paper or web.

The present volume is a reprint of the 1995 edition of *Chemical Thermodynamics of Americium*. As part of Phase II of the NEA Thermochemical Database Project (TDB), a new publication entitled *Update on the Chemical Thermodynamics of Uranium, Neptunium, Plutonium, Americium and Technetium* was published by Elsevier in 2003. For americium (and for the topics dealt with in the 1995 Appendix on uranium), this Update contains a review of the literature published since the cut-off date for the literature reviewed in the 1995 edition cited above. As a consequence of this new TDB Review, some of the values selected in the earlier publication have been superseded while others have retained their validity. The 2003 Update is self-contained with respect to any new data selections, but the discussions leading to the retained selections can in most cases only be found in the 1995 publication. Since the latter is no longer available from its original publisher, the NEA is making the present reprint available to the scientific community.

Chemical Thermodynamics of Uranium

Reprint of the 1992 Review

ISBN 92-64-02167-1 – Free: paper or web.

The present volume is a reprint of the 1992 edition of *Chemical Thermodynamics of Uranium*. As part of Phase II of the NEA Thermochemical Database Project (TDB), a new publication entitled *Update on the Chemical Thermodynamics of Uranium, Neptunium, Plutonium, Americium and Technetium* was published by Elsevier in 2003. For uranium, this Update contains a review of the literature published since the cut-off date for the literature reviewed in the 1992 edition cited above. As a consequence of this new TDB Review, some of the values selected in the earlier publication have been superseded while others have retained their validity. The 2003 Update is self-contained with respect to any new data selections but the discussions leading to the retained selections can in most cases only be found in the 1992 publication. Since the latter is no longer available from its original publisher, the NEA is making the present reprint available to the scientific community.

Nuclear Production of Hydrogen Second Information Exchange Meeting

Argonne, Illinois, USA, 2-3 October 2003

ISBN 92-64-10770-3 – Price: € 65, US$ 81, £ 45, ¥ 8 300.

Hydrogen has the potential to play an important role as a sustainable and environmentally acceptable source of energy in the 21st century. Present methods for producing hydrogen are mainly based on the reforming of fossil fuels with subsequent release of greenhouse gases. To avoid producing greenhouse gases, the possibility to use heat and surplus electricity from nuclear power plants to produce hydrogen by water cracking is being investigated. This report presents the state of the art in the nuclear production of hydrogen and describes the scientific and technical challenges associated with it.

Research and Development Needs for Current and Future Nuclear Systems

ISBN 92-64-02159-0 – Free: paper or web.

Research capability and technical expertise in the area of nuclear science are needed to maintain a high level of performance and safety of present nuclear installations, as well as to develop future-generation nuclear power programmes. The NEA Nuclear Science Committee (NSC) has completed a study on future research and development needs in specific areas of nuclear science, covering nuclear data; reactor physics and systems behaviour; and reactor fuels, materials and coolants. This report contains information on past and present international R&D activities conducted under the aegis of the NSC and on R&D needs for new nuclear systems in different NEA member countries. Recommendations for further work in the areas mentioned above are also given in the report. Possible follow-up actions to these recommendations will be considered by the NSC.

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