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

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



*Cover page: Decontamination activities at Saclay (A. Gonin, CEA, France), line construction (Vattenfall AB, Finland), decommissioning work at Windscale (UKAEA, United Kingdom), a PICSEL programme fire study at Cadarache (IRSN/DPAM/SEREA, France), decommissioning work at Yankee Rowe (NEI, United States).*

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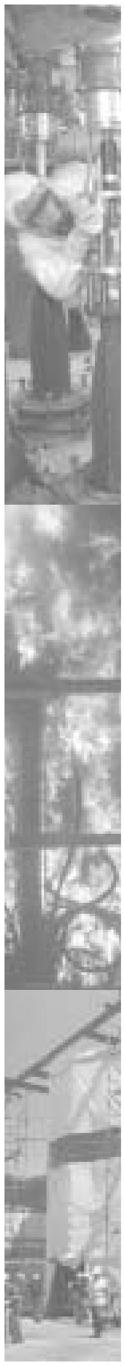

# Nuclear energy: a secure source of electricity supply

*The majority of NEA member countries agree that nuclear energy has a role to play in contributing to security of electricity supply. This was one of the conclusions of the NEA Steering Committee policy debate held in October 2005. Member countries also agreed that governments have a role to play in ensuring security of energy supply, as a complement to market forces. But ensuring such security is not a simple matter, and includes economic, technical and socio-political dimensions. Recent events reinforce this notion – notably in terms of potential impacts on national economies and international political relations – thus highlighting the various dynamics that can influence a given situation. The lead article on page 4 describes some of the main issues to be considered when addressing security of supply questions, and the role of nuclear energy therein.*

*Security of energy supply for electricity generation was also the theme of a joint workshop organised in 2005 by the NEA and the International Energy Agency (IEA). On that occasion, discussions addressed the full range of energy options. After having sought to shift the balance towards greater reliance on domestic sources of energy following the 1970s oil crises, OECD countries are now tending to adopt security of supply strategies which rely upon a diversification of energy dependence among several types of sources and suppliers. The United States is among those countries that are stressing a wider combination of policies. In the US case, efforts are also being made to improve energy efficiency and to carry out research and development activities in science and technology to provide for the long term. Regarding the specific role of*

*nuclear, workshop participants maintained that nuclear energy is often considered as forming part of secure energy supply mixes.*

*Yet for nuclear energy to form part of the energy supply mix of OECD/NEA member countries, it must be produced within appropriate and accepted safety levels, and without undue burdens being placed on future generations in terms of either radioactive waste management or the decommissioning of nuclear installations. Mirroring the comprehensive range of activities carried out by the NEA, this issue of* NEA News *offers several articles on subjects of high current interest. Readers may be particularly interested to note the article on "Funding the decommissioning of nuclear power plants". This article provides an overview of the funding principles and mechanisms in place across the OECD area. Specific details regarding prevailing policies in OECD/NEA member countries will be available in the NEA report to be published on this subject in mid-2006.*

Luis E. Echávarri
NEA Director-General

# Nuclear energy and the security of energy supply

**E. Bertel ***

**Security of energy supply was a major concern for OECD governments in the early 1970s. Since then, successive oil crises, volatility of hydrocarbon prices, as well as terrorist risks and natural disasters, have brought the issue back to the centre stage of policy agendas.**

Security of energy supply is clearly part of current government concern. Most often, the issue takes on added importance in OECD countries with energy-intensive economies and/or lacking fossil fuel resources. Despite this, after more than three decades of apparent threats on oil supply and prices, the global dependency of OECD countries on imported oil and gas has not been reduced. In fact, their levels of imports have increased and at the same time the demand from non-member countries, China in particular, has progressed at a high rate. This suggests that so far neither market mechanisms nor government policy measures have tackled the security of supply issue completely. Some of the key questions to be asked in order to do so, as highlighted in the findings of a recent joint IEA/NEA workshop on "Security of energy supply for electricity generation"[1], are:

- What is security of energy supply?
- Can it be measured and monitored?
- Is it an issue to be addressed by governments?
- What are the policy measures available to ensure it? And, last but not least,
- Can nuclear energy play a role in "secure" energy mixes?

## What is security of energy supply?

Defining security of energy supply is not an "academic" concern; it is a prerequisite, from a decision-making viewpoint, for designing adequate policy measures to ensure security of supply and for monitoring their effectiveness. The definition is needed up front to identify the risks raised by insecurity. Furthermore, the choice of the most efficient policy measures aiming at reducing those risks should rely on robust cost/benefit analyses that cannot be achieved without a clear definition of the goal pursued.

The notion of security of energy supply seems clear enough and may be defined in a broad sense as the lack of vulnerability of national economies to volatility in volume and price of imported energy. However, a precise definition of the concept specifying its boundaries is not easy to obtain. Security of energy supply has economic, social and political dimensions at the same time. Energy system analysts and economists can define the economic aspects, but the social and political dimensions are more difficult to capture. In addition, the analysis of energy system evolution shows that national policies aiming at security of energy supply have different objectives depending on the country context and global situation, and therefore follow different approaches.

It is generally agreed that insecurity of supply may result not only from physical disruptions, but also from increases in the prices of imported energy products. Physical disruptions may be caused by insufficient production or transport capabilities resulting from natural causes, socio-political conflicts or by abuse of market power on the part of monopolistic or oligopolistic producers.

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Similarly, a price increase might result from market mechanisms – demand exceeding supply – or from political decisions.

## Can security of supply be measured and monitored?

Generally, to assess the importance of a concern and to measure progress towards addressing it, policy makers rely on indicators. Examples of indicators designed by analysts and commonly used by policy makers in the energy field to evaluate the efficiency of alternative policy measures include gross domestic product (GDP), as well as primary energy consumption per capita and per GDP. Regarding security of energy supply, although some indicators have been proposed by economists or other experts, there is no consensus on a set of relevant indicators and consequently no historical series of data available to assess trends in the field.

A number of energy dependency indicators exist which have been measured, reported and stored in databases together with other energy indicators. For example, it is easy to find time series covering, for each imported energy source, ratios of domestic supply versus total requirements and respective shares of each foreign supplier in total supply. The level of strategic inventories and physical capacities of storage are also relevant indicators which are monitored by some countries and international organisations. But indicators of security of energy supply should represent a degree of risk and the risk associated with dependency varies according to the geopolitical situation of the supplier and importer countries as much as, or even more than, the size of imports.

Another way to quantify the value of security of energy supply is to consider it as an externality and to apply the methods used for valuing other externalities such as environmental impacts. Traditionally, environmental externalities are valued either through damage cost estimates or through the "willingness to pay" for avoiding those damages. Both approaches have proven difficult to apply to security/insecurity of supply and published literature on the subject matter remains scarce.

The complexity of the issue explains why well-established and commonly agreed indicators of security of energy supply do not exist yet. Decision makers, therefore, generally rely on a basket of parameters and qualitative assessments. Ongoing academic studies and empirical analyses of past experience provide some insights into trends in security of energy supply, but more needs to be done to gain a better understanding of the impacts of various policy measures. It is generally agreed that more research is necessary on quantifying benefits of security of supply in order to support policy making.

## What role for governments?

When the energy sector of OECD countries was regulated, governments were expected to take energy security into account by carefully planning the energy mix of their country, aiming at a diversified and secure portfolio of supply sources. As the liberalisation of energy markets is implemented progressively in all OECD countries, the role of governments in energy policy making is evolving. In liberalised markets, each supply source competes for shares on purely economic/competitiveness grounds, at least in principle, and decisions are taken by private investors not by governments.

In theory, the market should be sensitive to security risks and react accordingly. In the electricity sector, for example, if oil or gas supplies are interrupted or if prices rise dramatically, there is the possibility that electricity generating profits will suffer. However, the capabilities of liberalised markets to address security of supply concerns are not at all demonstrated. Recent trends, including the rush to gas for electricity generation, tend to demonstrate that markets are not very sensitive to security of supply risks.

Several reasons can explain the relative indifference of markets to security of supply. Maybe the market considers that the costs of reducing the risks of supply interruption would exceed the benefits of enhanced security. Or, perhaps the market relies on the government to alleviate the risks, confident that it will intervene for social and political reasons thereby eliminating economic consequences for private industry. Other reasons are quoted by experts but the point is that if markets fail to respond adequately, governments that wish to ensure security of energy supply for social as well as global macro-economic reasons must address the issue.

It does not mean that government regulation is always needed. The rationales for intervention have multiplied in recent years – the enviroment, climate considerations, energy security, protecting vulnerable groups, regional balance, and more.Over-regulating may make the investment climate hostile and be counterproductive. On the other hand, government regulation is a means to internalise external costs and to integrate social concerns in the establishment of market prices. The difficulty is to find the right balance between market mechanisms and regulation to ensure the result at the lowest cost to society.

## Measures for ensuring security of supply

Assuming that governments recognise the existence of security of supply risks and decide to address them, many policy measures are available to do so. Moreover, some measures that could address security of supply are also relevant for environmental protection and climate change risk mitigation purposes. The following non-exhaustive list of policy measures provides an overview of the main tools that governments may use to strengthen security of energy supply:

- promoting energy efficiency and conservation through norms, standards, information campaigns, subsidies, etc.;
- imposing a share of "secure" energy sources in new generation capacity;
- introducing taxes on "insecure" energy sources;
- subsidizing "secure/domestic" energy sources;
- supporting investments in energy storage options through norms or regulation;
- implementing tradable permits or certificates for secure energy sources.

Clearly, the list illustrates that the task for governments is to select a relevant policy taking into account uncertainties on indicators and potential adverse impacts of regulation on the effectiveness of energy markets. The adaptation of policy measures to the national context and the evolution of the security of supply risk also raise some issues. For example, political events beyond the control of energy policy makers, such as conflicts in major oil-producing regions of the world, may change drastically the security of oil supply and thereby the value of policy measures taken to alleviate the risks associated with imports from these regions.

As is the case with measures for environmental protection, measures aiming at energy efficiency are win/win options for security of supply as they reduce total demand. Measures to promote domestic sources enhance security of supply, but should be assessed taking into account the relative costs of domestic versus imported sources.

Comparisons between the costs and benefits of enhancing security of supply are essential in support of decision making. Indeed, if the costs are higher than the benefits, society as a whole is losing. The first part of the equation is simple to evaluate in general, but the second is not easy to quantify. Indeed, measuring in strict economic terms the cost of insecurity or the benefit for consumers of secure energy supply at affordable prices is not straightforward. Macroeconomic models and assessments provide some insights into the impact on the national economy of insecurity of energy supply. But ultimately, society's willingness to pay to avoid power cuts and/or gasoline price spikes should be estimated, albeit with some difficulty.

## The role of nuclear energy

Nuclear energy offers opportunities for diversifying energy supply and ensuring long-term security. Once technology transfer, if needed, has been achieved, nuclear power plants provide a largely or entirely domestic supply of energy. For this reason, several OECD countries consider nuclear energy as a key policy option for improving security of supply.

The main advantages of nuclear energy in this regard are the limited importance of raw material – natural uranium – in the entire fuel chain producing nuclear electricity, the geopolitical distribution of uranium resources and production capabilities, and the easiness for users to maintain strategic stockpiles of fuel.

Natural uranium is widely available in the world, including in many countries where the geopolitical risk is limited. Its cost represents only a few per cent of the total cost of generating nuclear electricity and therefore uranium price volatility is not a major concern for nuclear power plant owners/operators. Furthermore, maintaining strategic stockpiles representing several years of consumption is physically easy and does not represent a significant financial burden for users.

Reasonably assured uranium resources recoverable at less than 40 USD/kgU represent 25 years of consumption at the present level, while known and total conventional resources recoverable at less than 130 USD/kgU represent respectively 65 and 200 years of consumption. Furthermore, advanced reactors have the potential to reduce significantly the specific consump-

**Availability of uranium resources**

| | |
|---|---|
| **Million tU** | |
| Reasonably assured resources <40 USD/kgU | 1.7 |
| Known conventional resources <130 USD/kgU | 4.6 |
| Total conventional resources <130 USD/kgU | 14.4 |
| **Years of consumption at 2005 level** | |
| Reasonably assured resources <40 USD/kgU | 25 |
| Known conventional resources <130 USD/kgU | 65 |
| Total conventional resources <130 USD/kgU | 200 |

tion of uranium per kWh of electricity generated; fast neutron breeder reactors, for example, can multiply by 50 or so the amount of energy extracted from natural uranium.

In terms of security of supply the geopolitical distribution of uranium resources and production guarantees against risk of disruption. Known uranium resources are found in countries as diverse as Australia, Canada, the United States, Kazakhstan, the Russian Federation, Namibia, Niger and South Africa. Most producing countries, e.g., Kazakhstan, Niger, Namibia, the Russian Federation and the United States, contribute less than 10% to the total. The two major producers, Canada and Australia with 27% and 20% of the total respectively, are OECD countries.

**Shares of uranium resources and production**

| | % of resources* | % of production** |
|---|---|---|
| Australia | 23 | 20 |
| Canada | 12 | 27 |
| United States | 7.5 | 2 |
| Namibia | 5.5 | 7 |
| Niger | 5 | 8.5 |
| South Africa | 8.5 | 2.5 |
| Kazakhstan | 18.5 | 9 |
| Russian Federation | 6 | 8.5 |
| Uzbekistan | 2.5 | 6.5 |
| Ukraine | 1.5 | 2 |

* Total known resources recoverable at less than 130 USD/tU; ** in 2003.

The various other steps of the fuel cycle present different degrees of security of supply. Some fuel cycle services, such as fabrication and transport, are provided by a wide range of suppliers ensuring security and competitive prices. For others, such as enrichment and reprocessing, the number of suppliers is more limited and the competition less effective. However, there has been no example of supply disruption or signs of risk in this field in the past.

In addition to uranium resource availability, safety, physical protection and non-proliferation regulations may have an impact on the reliability of services delivered by nuclear power plants and the security of nuclear material supply. However, past experience with more than 10 000 reactor-years of operation has shown that such issues have not affected the reliability of nuclear electricity supply.

In countries where a large fleet of standardised reactors is in operation, generic safety problems could require shutting down simultaneously multiple units for refurbishment and upgrade. But such a threat has been a strong incentive for regulators and operators concerned to take efficient preventive measures. Similarly, the evolution of safety regulations could entail in principle extensive unavailability of nuclear power plants needing safety upgrades. However, operators have been able in the past to meet strengthened safety standards without jeopardizing reliability and security of electricity supply.

The international safeguards regime aiming at preventing proliferation of nuclear weapons creates some constraints on nuclear fuel markets associated with declaration, controls and verification of the peaceful uses of nuclear materials. The framework implemented under the auspices of the IAEA does provide, however, a well-defined set of stable rules. Within this framework, complemented by national laws and regulations, nuclear materials for peaceful uses can be traded freely between countries and operators.

## Concluding remarks

Energy policy is based on many factors including economic competitiveness, social equity, environmental protection and industrial development goals. From a long-term perspective, the overarching goals of sustainable development will provide the framework for policy making in the energy field, as in other sectors of the economy.

In this context, security and diversity of supply, with their social, environmental and economic dimensions, will remain key drivers in the energy policies of most countries. Better understanding the challenges facing governments and the policy measures available to address them should help in designing and implementing efficient policies. Analysing the role of all energy options, including nuclear energy, is needed to base policy measures on comprehensive, robust assessments. ■

**Note:**

1. The proceedings of the workshop, held on 24 March 2005 at IEA Headquarters, are available on the IEA and NEA websites.

# Evolving roles and responsibilities in radiological protection

**T. Lazo ***

**One of the only truly consistent things in life is the knowledge that things will continue to change. In the area of radiological protection, change is not always fast, and it is not always deep, but it has clearly been present over the past 10 to 20 years. These changes will all have more or less profound effects on the roles and responsibilities of the radiological protection profession. This article presents an initial analysis of these changes, with a view to helping those concerned be better prepared to meet the challenges that may arise.**

Society's approaches to protection against ionising radiation have significantly evolved over the past decades. Historically, radiological protection was introduced before the Second World War by the medical community seeking to protect itself and its researchers from the harmful, deterministic effects of ionising radiation, based on the possibility of genetic effects identified in fruit flies. In the years that followed, attention shifted, as a result of Manhattan project atomic weapons research, from medical aspects to the physical description of energy transfer and absorption, and to increasingly sensitive detection of all types of radiation. Early norms for radiation exposure were developed, with deterministic effects being the key focus. However, after the explosions at Hiroshima and Nagasaki, the cancer-causing potential of exposure to ionising radiation was highlighted, and this has become increasingly central to radiological protection concerns. Over all these periods, knowledge of radiation risk has increased, through both biological and epidemiological studies. Considerable uncertainty remains nevertheless.

Since the social upheavals of the 1960s, the barriers that once surrounded risk assessment and management decisions and decision-making processes, in all areas involving decisions regarding risk management, have increasingly been disappearing. The days when well-meaning public officials and technical bureaucrats could, to the best of their judgement, make public-protection decisions in isolation are gone. Today, many groups and individuals wish to be involved, at various levels of participatory democracy, in discussions and decisions affecting public health and environmental protection. Individual members of the public subject to particular risks, local and national groups and associations (often called non-governmental organisations, or NGOs), and even federal, state and local government offices not directly responsible for decisions often feel that their views should be taken into account during any public decision-making process, and that their concerns need to be addressed. These individuals and groups, as well as the responsible regulatory authorities, along with the risk-causing facility/process operator when applicable, have come to be known collectively as stakeholders. Stakeholder involvement in decision-framing and decision-making processes involving any and all public, worker and environmental risks is increasingly common in today's world. Stakeholders question the role of science and authorities in risk decision

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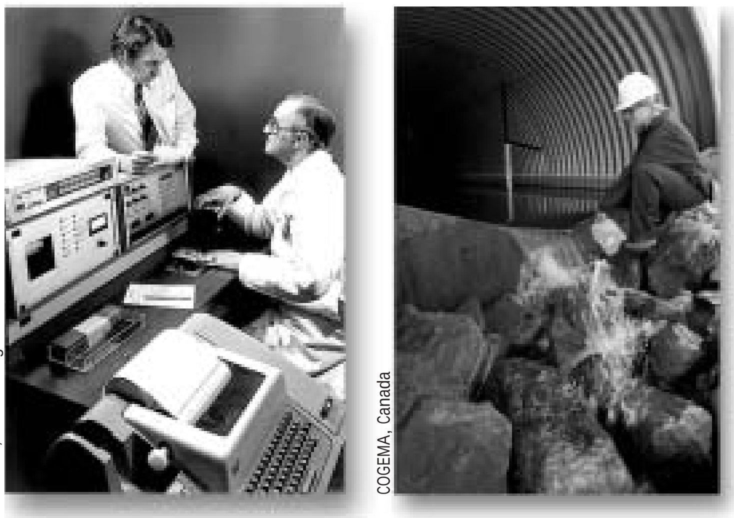

UKAEA, United Kingdom

COGEMA, Canada

Radiological protection has evolved significantly over the past 20 years.
Shown above, dose assessments in 1980 (left) and 2000 (right).

making, and demand accountability in decisions regarding the management of risks.

This growing interest in risk-related decisions reflects many different aspects of social and scientific evolution. For example, the media, and the current information-oriented society in general, have made information on risks much more available to everyone. At the same time, the technological promises of post-World War II advances have often not lived up to initial claims, breading some scepticism of science and public institutions. With this has come the growing realisation that science is only part of "the truth" with respect to judgemental decisions affecting such things as "safety", "security" and "the environment". Increasingly, social values emerge as significantly more influential than scientific fact with respect to such decisions. This, in tandem with technology and the availability of information, have made it possible for an individual to manage her or his own risks much more actively.

Many other structural and social changes have also contributed to shaping modern radiological protection, including:

- The world has become much more of a "global entity", thus requiring global, social harmonisation in a broad sense. At the same time, cultural and regional specificities must be recognised, such that it is clear that there is no single "risk rationale" to dealing with risks, and there is no inherent social contradiction if the management of risk is not approached everywhere in a comparable or "equal" fashion, particularly in terms of stakeholder concerns and resource allocations.
- Even as global issues become more widely recognised, there is a trend that local contexts are increasingly important to decisions involving radiological risks. Thus policies, regulations and applications are seen through a hierarchical prism, in such a way that, because of local specificities, aspects at the international level can be subsidiary to those at the national level, which can in turn be subsidiary to local aspects.
- The notions of sustainability and intergenerational awareness have introduced a much longer view in any planning discussions. This is particularly relevant in terms of what is meant by "progress", and with respect to the "margin" within which work can or should take place, the objectives for projects, and the expected speed of projects.
- Environmentalism has continued to grow, to the point where increasingly, and at many levels, there is a link between good public health and a healthy environment. Much of the public demand for a clean environment is thus formulated on the basis of good public health. These notions, both as social values and as scientific facts, are central to many of today's decisions and decision-making processes.
- There is a growing view that although radiological protection has for some time been fairly independent, it should rather be considered within the broader sphere of public health. In this context, the assessment and management of radiological risks are, as with environmental protection, reformulated to be addressed together with many other risks and issues and to achieve good public health in a balanced fashion.

## Changing roles and responsibilities of radiation protection professionals

The slowly evolving social changes described above have formed a new picture of the role of radiological protection, the key to this new outlook being the relationship between "judgement" and "science" as applied to a particular circumstance. In this context, radiological protection (RP) can be seen in a new light.

The RP professional has always been, and continues to be, focused on the scientific aspects of a particular situation being considered, in order to select the "best" public, worker and environmental protection options. This can be characterised schematically as evaluating the identified radiological risks, and optimising protection to reduce risks. However, what was once a rather quantitative, numerically driven assessment of costs (e.g. of implementing protection options, of addressing health risks from any residual doses, etc.) and benefits (e.g. of saved health costs due to dose reductions), has become in some circumstances a more nuanced, qualitative assessment of the overall risks and benefits of the dose-causing activity (or dose-reducing activity in the case of existing or accident-related exposures). This can include:

- a careful categorisation of risks and benefits, attributed as a function of various characteristics: for example the age, sex, geographic location and exposure time frame of the relevant population;
- the "identification" and "highlighting" of judgemental aspects of the assessment such as the selection of critical group habits and characteristics, the use of numerical screening or boundary values in selecting options, the selection of exposure scenarios, and the selection of weighting values, if any, for various parameters.

In this context, the focus of the RP specialist is the use of radiation protection science, at its highest levels, for clarifying the results, implications and nuances of various protection options. The identification of the "best" protection option, which will be recommended to the "decider" as the preferred solution, will clearly be very judgemental in nature. For this identification, the RP professional will, of course, use personal judgement. However, the judgements of the other relevant stakeholders (e.g. the exposed groups, non-decisional government offices, etc.) will equally be important. Their concerns (such as doses to children, doses to future generations, property values and policy ramifications) will in many cases be those that ultimately drive the risk and benefit assessment. Their judgements (of their benefits, of the various assessment parameters chosen, of the acceptability of any residual risks) will more than likely be those that are most highly considered by the decider in making the final decision.

This characterisation of the role of the RP professional may seem to represent a loss of responsibility in comparison to the more traditional model in which the decider relied much more directly upon the judgement of the RP professional. This new view, however, is far more challenging in the sense that the RP professional must not only bring state-of-the-art RP science to bear on the question, but must also present results in a fashion that is understandable and relevant to the stakeholders and the situation at hand. So rather than this being viewed as a loss of responsibility, it can be viewed as a broadening of responsibility, in that a wider group than just the decider will rely upon the work and judgement of the RP professional.

The refocusing of the role of the RP professional can be seen as the practical application of the theoretical distinction between the role of the decider and the role of the RP specialist. There is a clear process boundary between the decider, who is a government official or a corporate officer legally or contractually responsible for making a decision, and those providing information for the decision-making process. As discussed previously, decisions are inherently judgemental, but will be based, at least in part, on input from radiological protection specialists. In this context, the role of the RP specialist is then to provide the decider, and stakeholders, with relevant scientific information such as:

- assessments of absolute and relative levels of risk;
- uncertainty assessments;
- sensitivity analyses based on stakeholder-specified parameters;
- assessments of the effects of various RP options.

In many cases, the decider may well be an RP specialist. However, by separating the function of assessment from the function of deciding, the judgemental nature of many of the decision elements in the process will be much more transparently expressed. This will facilitate making any necessary assessment iterations by appropriately identifying the elements that could be modified to yield results that are more relevant to stakeholders.

A particular challenge that this evolution poses to the RP specialist concerns education and training. Traditional engineering and RP science training has focused on technical aspects, yet RP specialists are increasingly being called upon to interact and communicate with diverse stakeholder groups, and to be able to provide technical information to these groups in forms and formats that address stakeholder needs and concerns. Although it will clearly not be necessary to train RP specialists to be "public relations experts", it is important that they be trained to communicate in both technical and non-technical manners such that their essential messages can be correctly assimilated in decision-making processes.

## Development of radiological protection principles and policies

Beyond the clarifying effects that social changes have had on the roles and responsibilities of RP professionals, they have also had profound effects on the way that radiological protection principles are developed, interpreted and reflected in regulation and practice.

Throughout the 20th century, radiological protection principles have been developed by RP professionals, and these principles have been accepted by virtually all governments worldwide. The notion of stakeholder involvement, and of pluralism in decision making, is increasingly important, and may significantly modify the process for the development of these principles. Given the discussion of context in decision making, "prevailing circumstances" may well lead to local decisions. Such flexibility is necessary, but some level of international harmonisation is also needed to the extent that we live in an open world. The balance between international harmony and local specificity must therefore be a central issue in the future development of radiological protection principles.

The question of roles and responsibilities should be viewed in the broader context of an evolving view of international harmonisation in radiological protection. The justification of exposure-causing activities (and the optimisation of protection and restriction of exposure that go along with these activities) is seen in the context of social choices (including, but not limited to, scientific input), which are inherently focused on the situation at hand.

Until the latest discussion of new ICRP recommendations began in 1999, when the ICRP Chair published a paper discussing "Controllable Dose", the ICRP process of developing recommendations was exceptionally closed. This reflected the previous reality of radiation protection being solely seen as "good science", rather than the emerging view of radiation protection as a social judgement informed by good scientific knowledge.

Since the opening of discussions on the new ICRP recommendations, however, the process has significantly changed, in what will most likely be an irreversible fashion. Draft materials are developed by the ICRP, but these are then broadly discussed with various stakeholder groups. Comments are received, and new recommendations are developed taking these into account.

It should be recalled that the recommendations of the ICRP have always required much interpretation in order to transform them into international standards and national regulations. The discussion of draft recommendations, embodied in the new process of recommendation development, will hopefully result in final ICRP recommendations that are more easily translated into practical application in standards and regulations.

But the ICRP is only one of the key stakeholders in radiological protection. The roles and responsibilities of various organisations are essential in the development of scientifically sound, easily applicable approaches to radiological protection. Although the details of roles and responsibilities tend to evolve over time, it appears that for the coming years the key international organisations will play the following roles:

- UNSCEAR: collection and scientific assessment of radiological health risks;
- ICRP: development of RP principles, and consolidation of understanding;
- NEA: development of foward-looking views, input to principle development, interpretation and understanding of key principles for application;
- EC: translation of consensus into EC laws;
- IAEA: globalisation of principles, translation of consensus into world standards;
- WHO/FAO: examination of the RP aspects of public health standards;
- IRPA: diffusion of information (top-down), collection of views from RP professionals (bottom-up).

## The role of the CRPPH

The NEA Committee on Radiation Protection and Public Health (CRPPH) has been actively involved in the discussion and development of radiological protection principles, practices and consensus. Within the evolving processes that have previously been discussed, the CRPPH remains a unique resource, with many characteristics and qualities of value to its member countries. Looking both forward and back, those that stand out most significantly include:

- embracing stakeholder dialogue;
- assessing the implications of radiological protection science;
- developing key tools;
- partnering with the ICRP.

While not fully characterising the qualities and work of the CRPPH, these attributes broadly describe the platform from which the Committee will continue its efforts. Its forward-looking, brainstorming approach will continue to evolve to best meet the needs of its members, to serve the radiological protection community, and to help to improve public, worker and environmental health. ■

# The NEA and the IAEA: partnering for progress

**G.H. Marcus ***

We are often asked, "What is the difference between the OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency (IAEA)?" Or, to put it bluntly, why are two international intergovernmental agencies needed in the nuclear field?

It is entirely reasonable for governments and interested individuals to ask this question. After all, on the surface, there appear to be substantial similarities in the areas of effort of the two organisations, and no member countries should have to support redundant efforts or, worse still, for international civil servants to waste time and effort in pointless turf battles.

I am happy to say at the outset of this article that a careful analysis shows that each agency has different areas of emphasis and different strengths. Furthermore, the senior managers of both agencies are committed to co-operation and co-ordination. As a result, we believe that the work of the two agencies is complementary. The different expertise and different focus of the two entities, when applied to joint efforts and to sharing of efforts, results in a cumulative effect which is greater than the sum of the two parts.

An understanding of the fundamental differences between the IAEA and the NEA can help put things in perspective. The NEA is an organisation of 28 market-oriented, liberalised economies. The IAEA, by contrast, currently has 138 member countries, and includes the majority of the developing world. All NEA members are also IAEA members. The NEA is a semi-autonomous organisation of the Organisation for Economic Co-operation and Development (OECD), while the IAEA is an autonomous international organisation within the United Nations family of organisations. Those member countries of the NEA that operate commercial nuclear power plants collectively produce over 80 per cent of the world's nuclear-generated electricity. Nuclear power supplies about one-fourth of the electricity in NEA member countries, as compared to 16 per cent of the electricity generated worldwide.

The mission of the NEA is to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes; and to provide authoritative assessments and to forge common understandings on key issues as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development. Therefore, the NEA focuses on selected areas where the member countries seek such authoritative assessments and the development of common understandings. The mission of the IAEA is to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world; and to ensure, so far as it is able, that assistance provided

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by it or at its request or under its supervision or control is not used in such a way as to further any military purpose. Thus, the IAEA mission encompasses all areas of nuclear technology, including those that are useful to the developing world, and a very important part of its mission relates to assuring that the use and dissemination of nuclear technology does not lead to the further proliferation of nuclear weapons around the world.

These are very different missions, and as a result, the NEA does no work in most of the areas in which the IAEA operates. While the NEA believes non-proliferation is important, it does not conduct any work in this area. The NEA does not engage in any work on non-proliferation policies or international agreements, and does not participate in inspections to assure compliance with non-proliferation treaties. The NEA also has no involvement in providing technical assistance to the developing world, which is a major focus for the IAEA. The NEA does not provide funding for the dissemination of nuclear technologies or training for their use. The NEA does not have any activity in many of the technological areas where the IAEA has done extensive work – such as in the use of nuclear technology for agricultural applications.

Nevertheless, there are technological areas of common interest to both organisations. Both organisations are interested in the safe operation of reactors, now and in the future. Both organisations work on other aspects of the nuclear fuel cycle, including waste disposal. Both organisations are concerned with the effects of radioactive exposure on workers and members of the public. Both organisations engage in economic and development studies, and work in some of the scientific areas underlying nuclear technology.

What helps keep the work of both agencies separate in these areas is the different technical and political areas of interest of both organisations, and their very different modes of operation. The NEA, with its small staff and budget (about 80 people and a budget of 12.5 million euros[1]), cannot provide assistance to its member countries in all areas. Indeed, its member countries, with their highly developed infrastructures, their extensive research programmes, and their considerable experience with nuclear technologies, do not feel the need for assistance in all areas. The work of the NEA is guided by a Steering Committee composed of its member countries that has promulgated a five-year Strategic Plan to direct the efforts of the agency, and that develops biennial work plans consistent with that Strategic Plan. The Strategic Plan, and the biennial work plans, call for work to be focused on areas of member country interest. For example, the agency does not, at present, do much work in the area of low-level waste disposal, but rather focuses its efforts solely on high-level waste disposal.

NEA staff has strong expertise in the areas of work the member countries wish to pursue. Further, the NEA's products are generally not products of the permanent staff or consultants, but rather products of its committees and working parties. These committees and working parties pool the best expertise around the world and develop products that represent a consensus of the world's experts in a given area. It should be noted that the NEA's committees and working parties invite the collaboration of non-member countries to participate in their activities as appropriate, including as either ad hoc or permanent observers. The number of such collaborations is limited, but it does include those countries outside the NEA, such as Russia and China, that have substantial nuclear activities and an ability to contribute substantively to the work of the committees, as well as to gain from their participation.

Another strong focus of the NEA is its experience in providing Secretariat services for international research projects. We currently serve this function for over a dozen such special projects, many of them in the safety area. It is worthwhile to point out that these projects may involve countries that are not members of the NEA. For example, the recently completed RASPLAV project and the current MASCA project both utilise research facilities in Russia.

While at first glance it may seem that the NEA's smaller membership might be limiting, in fact, it has turned out to be a strength. The smaller, more homogeneous membership of the NEA simplifies decisions on which countries to involve and how materials can be shared. Projects are naturally multinational rather than global, and as appropriate, may be initiated with only a subset of the NEA membership. Coupled with that, the ability to involve selected non-member countries helps assure that other perspectives are brought to the table as appropriate.

The different missions and memberships of the two organisations have resulted in complementary strengths. While the NEA's organisational structure and processes are designed for supporting multinational projects in emerging areas of technology, the IAEA's structure and activities are more appropriate for the dissemination of insights and products worldwide. On a number of occasions, the IAEA has taken a tool piloted by the NEA for multinational applications and further developed it for a worldwide audience. Just as importantly, the NEA and the IAEA have worked in partnership on numerous projects to develop applications that meet the needs of both of their constituencies.

Two prominent examples of mutual effort are the IAEA/NEA Incident Reporting System (IRS) and the International Nuclear Event Scale (INES). The IRS was initially developed to collect information on potential safety-related events at nuclear power plants (NPPs) and to provide it to regulatory authorities. It has since evolved to address not only power installations, but also research reactors and fuel cycle facilities around the world. INES was developed as a means to communicate promptly to the public the safety significance of events reported at nuclear power plants. It also has been subsequently expanded to address events at all types of nuclear installations as well as occurrences associated with the transportation of radioactive materials and the use of radioactive sources.

Both of these products logically needed to be used worldwide for maximum value. The NEA's smaller membership, with a number of members who had tools of their own in these areas, was able to initiate activity quickly in the development of these products. The IAEA, with its wider membership, expanded the scope of these tools and was, ultimately, the organisation most appropriate for their long-term management. The NEA has continued to work with the IAEA on both these systems, jointly managing the IRS and as a member of the Advisory Committee for INES. Thus, the development and implementation of these systems has followed a symbiotic, mutually beneficial path.

The IAEA's broad membership also makes it the appropriate organisation for providing for reviews of safety performance at nuclear power plants throughout the world in order to promote the continuous development of operational safety globally, such as through its Operational Safety Review Teams (OSARTs); for assisting countries as needed in developing their infrastructures for the safe and effective operation and regulation of nuclear facilities, such as through training; for providing a global forum for discussion of and advice on safety issues at nuclear installations, such as through its International Nuclear Safety Group (INSAG); and for setting basic standards of safety to help assure that regulatory standards throughout the world adhere to certain fundamental principles.

The different strengths of the two organisations have, from time to time, caused their member countries to seek the assistance of one or another of the organisations in specific activities. Thus, countries within the IAEA encouraged the establishment of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) as a vehicle to help member countries assess current and emerging nuclear technologies and make effective decisions on what technologies are best suited for each country's needs. Likewise, the membership of the Generation IV International Forum (GIF), which is largely, but not exclusively composed of NEA members, sought out the NEA to tap into its experience in co-ordinating research projects by asking it to serve as the Technical Secretariat for GIF.

Although it is clear from the above that there is a distinct and complementary role for each of the two organisations in areas of common interest, it is also true that, without some conscious co-ordination, what begins as a complementary activity can turn into a duplication of effort. The two organisations have, over the years, developed co-operative links at all levels of both organisations. The links include ongoing contacts between project managers of related activities in both organisations, and an annual co-ordination meeting at the senior management level to discuss plans in each agency for the coming year.

These communications have led the two agencies to pool their expertise on a number of joint activities, including conferences and publications, and to participate actively in each other's committee meetings and conferences.

Thus, through a combination of the differences between the missions and working methods of the two agencies, and through the strong links established, the NEA and the IAEA provide complementary and co-ordinated services to their member countries in areas of mutual interest. ■

**Note:**

1. In comparison, the IAEA has about 2200 employees and a regular budget of about US$ 300 million, but it should be noted that these figures include staff and resources for all activities, not just the ones in areas of common interest.

# Funding the decommissioning of nuclear power plants

**O. Söderberg, C. Pescatore, T. Eng ***

The average age of nuclear power plants in OECD/NEA member countries is now about 18 years. The average operating lifespan is estimated to be 30-50 years with a trend towards lifespan extensions. It follows that the rate of withdrawal from operation will peak somewhere after 2015. In several countries a number of commercial nuclear power plants have already been shut down. In some cases, decommissioning and dismantling have been completed or are in progress. In other cases, strategic, conceptual and/or detailed planning for such activities is currently taking place.

The purpose of decommissioning and dismantling is to remove on-site hazards that could potentially affect the long-term safety of the public and the environment, while continuing to protect the health and safety of decommissioning workers involved in the process, and with the objective of arriving at a state at which some or all regulatory controls no longer apply to the site. A characteristic feature of policies and strategies for the decommissioning of nuclear power facilities are the relatively long time horizons involved. Thus, today's generations have to make – and are already making – decisions with potentially far-reaching consequences for future generations.

The decommissioning of a nuclear power plant might well start 50-60 years after the facility became operational. In fact, a century or more could elapse between the construction of a nuclear power plant and the completion of decommissioning. This time horizon is outside the range of traditional economic and political decision making. Careful and early planning is also important because the costs involved are large. A recent NEA study[3] shows that the average decommissioning cost is about US$ 320M for a 1000 MWe pressurised water reactor (PWR) and US$ 420M for a 1000 MWe boiling water reactor (BWR).

Financial assets or funds to cover decommissioning costs are currently being set aside in most countries with nuclear power programmes. The mechanisms for accumulating and managing these funds, as well as the types of costs to be covered by the funds, differ from country to country.

Most topics mentioned above have been addressed in recent NEA work and discussions[2,3,4,5,6]. A number of conclusions have been drawn and are outlined in the paragraphs below. Many of the following considerations are equally applicable to non-nuclear facilities, such as chemical plants or other facilities containing toxic materials.

## Ethical principles for decommissioning funding

When formulating principles for funding and sharing the costs of decommissioning, concepts such as equity and justice are indispensable:

- The current generation has an obligation to collect and to preserve the financial, technical and scientific resources necessary for the future decommissioning of nuclear power facilities.
- The generally acknowledged "Polluter Pays Principle"[1] should be applied when funding the costs of decommissioning nuclear power facilities.

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Before, during and after the decommissioning of the Maine Yankee NPP in the United States (completed in 2005).

- Funding the costs of decommissioning nuclear power facilities should be guided by the principle of avoiding the imposition of undue burdens on future generations.
- A principle of intergenerational continuity, whereby the present generation transfers resources and reasonable obligations to the succeeding generation, should apply when formulating principles for funding and sharing the costs of decommissioning.

The principle of avoiding imposition of undue burdens on future generations is found in the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*. It is left to the Contracting Parties to decide how to achieve this. The Convention also states that adequate financial resources should be available to ensure the safety of decommissioning a nuclear facility. Access to human and financial resources is considered to be part of general safety provisions.

The principle of intergenerational continuity implies a *chain of responsibility*. A key element when applying the principle of intergenerational continuity is the creation and preservation of a system for funding decommissioning when needed. The collection and administration of funds for decommissioning should fulfil stringent criteria of financial ethics, including:

- preservation, and possibly an increase, of financial resources;
- robustness (independence from a variety of societal, political and economic scenarios);
- transparency;
- availability when needed.

## Establishing a funding system

The experience from NEA member countries is that many aspects are to be considered when setting up a funding system. Experience also shows that there are a number of ways to establish adequate funding systems.

First of all, decommissioning liabilities should be identified and properly managed. This is a prerequisite for all cost calculations. First steps include the establishment of a register of the location and the state of all nuclear installations and all sites that contain radioactive materials; estimation of the costs of their dismantling and remediation; evaluation of the existence and adequacy of the provisions for financing these future or current operations; and the updating of this register on a regular basis.

Basic options for decommissioning strategies are immediate/early dismantling (within approximately ten years after operation phase-out), deferred dismantling (typically 30-50 years after) or entombment (on-site encasing of the radioactive material). Generally speaking, planning for decommissioning should start as early as possible, ideally at the design stage of the facility. A regulatory framework and facilities for waste handling and storage (or disposal) are necessary pre-conditions to begin the decommissioning of any facility. Co-operation and co-ordination between implementers, regulators and stakeholders are critical.

Experts have also found that decommissioning cost estimates must be made on an iterative, site-specific basis and are a prerequisite for adequate funding. There is no universally accepted standard for developing decommissioning cost estimates. In developing a funding basis for a decommissioning project, sufficient margins should be included to account for uncertainties. The main costs involved are highly dependent on the project in question and on country-specific factors.

A legal framework is required for the creation of decommissioning funds and for ensuring that the funds will not be inappropriately diverted for other purposes. The funding system should be based on the "Polluter Pays Principle", and should meet minimum criteria of sufficiency, availability and transparency.

A funding methodology must also be developed. Mechanisms for providing adequate funding for decommissioning nuclear power plants exist in NEA member countries with nuclear power programmes, but they vary according to different national legislation and practices.

The main type of funding arrangement in NEA member countries is based on a gradual build-up of the funds. In most cases, funds are set aside for decommissioning based on nuclear electricity production (kWh). Another way of raising the funds can be through a levy on sales of electricity (as in Italy and Spain). The funds can be managed internally within the operating organisations (such is the case in Canada, Germany and the Netherlands) or by external bodies (as in Finland and Sweden).

Estimating the contributions to be paid is a crucial step. Calculations are based on the estimated decommissioning costs, assumptions with respect to the time at which the costs will arise, inflation, and the anticipated interest rate on the accumulated capital. In addition to successive contributions, the growth of the fund is dependent on the investment strategy, i.e. how aggressively or conservatively the funds are invested. A proper balance is obviously required between maximising the return on the investment and the conservative approach needed to protect the capital in the fund.

Competent administration of the funding system is of paramount importance. Legal rules must ensure that funds collected cannot be diverted. Regular and frequent reviews of all calculations of future costs are vital. The real value of assets in the fund must also be safeguarded against inflation.

## Decommissioning funding uncertainties

When creating a funding system there will always be uncertainties which have to be evaluated, and measures must be implemented to minimise them. Such uncertainties can be grouped into four interdependent areas.

*Estimation of decommissioning costs.* Minimising uncertainties of this kind involves continuous development of cost estimates and using the lessons learnt from other decommissioning projects. Such reassessments of decommissioning costs should be undertaken throughout the operational phase of a facility.

*Early shutdown consequences.* An early shutdown means that financial resources for decommissioning have to be covered by other sources. To insure against such an eventuality, a system for alternative financing should be planned at an early stage.

*Availability of funds.* Assets have to be available when needed for their purpose. Careful liquidity management is therefore essential and reliable forecasts of when major costs will arise are a prerequisite for ensuring the availability of funds when needed.

*Managing funds over long timescales.* If the fund's capital is managed in order to provide a positive return, it is exposed to various financial risks such as inflation, market fluctuations, credit loss, liquidity problems and changes in currency exchange rates. These types of financial risks are the same for all kinds of capital management and must be addressed.

## Key messages and conclusions

Three key messages can be derived from recent NEA activities addressing decommissioning:

- In NEA member countries with nuclear power programmes, mechanisms are in place for providing funding for the decommissioning of nuclear power plants. These mechanisms may differ according to different national legislation and practices.
- Existing systems and practices for funding decommissioning of nuclear power plants are in agreement with widely accepted ethical principles and, in particular, with the principle of not imposing undue burdens on future generations.
- The availability of funds at the right time is one of the cornerstones of a successful funding system. The identification of related uncertainties, and the implementation of measures to minimise them, are essential for ensuring this availability. ■

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# Lessons from 40 years of nuclear safety and regulation

**B. Kaufer ***

The year 2005 marks 40 years of successful multilateral exchanges through NEA committees concerned with nuclear safety research and regulation. The first multilateral safety committee set up in 1965 under the European Nuclear Energy Agency (forerunner to the NEA) was the Committee on Reactor Safety Technology (CREST). The first CREST meeting covered major technical issues of the time such as depressurisaton accidents, shock in reactor structures (TNT tests), hot particle problems (fuel elements) and the initiation and propagation of cracks in pressure vessels. Restructuring took place in 1973 when the Committee on the Safety of Nuclear Installations (CSNI) was set up to replace CREST.

The mandate of the newly created CSNI stated that it was responsible for examining technical aspects of nuclear installations and for establishing a dialogue between regulators and research organisations with the dual purpose of assisting in the definition of research objectives and providing feedback on research results to nuclear regulators. The CSNI Subcommittee on Licensing was to provide a forum for licensing authorities, covering aspects that were not strictly technical or scientific in nature.

By the end of the 1980s, it became evident that the public was becoming concerned with regulatory practices. In response, there was a growing appreciation among regulators in OECD/NEA member countries of the need to demonstrate that regulatory practices had a consistent technical basis that led to uniformly high standards, and that, in fact, differences in these practices were more apparent than real. In addition, the expanding body of operational experience and lessons learnt could be applied to regulatory practices, and the accumulation of regulatory experience provided a strong basis for exchanging information and understanding on national approaches. Following discussions in the CSNI and other NEA committees, and NEA Steering Committee agreement, the Committee on Nuclear Regulatory Activities (CNRA) was created in 1989 to guide the NEA's programme concerning the regulation, licensing and inspection of nuclear installations with regard to safety.

## The NEA Safety and Regulation Forum

In commemoration of 40 years of successful co-operation on nuclear safety issues, the CSNI and the CNRA joined together this past June to reflect on what has been learnt; what challenges are foreseen in the future; and whether the NEA arrangements that, in conjunction with other international organisations, have served the international community well in the past, remain appropriate for future challenges. This reflection took place within the NEA Safety and Regulation Forum on Multilateral Co-operation in Nuclear Safety Research and Regulation.

Over 100 participants attended the NEA Forum, which was held on 14-15 June 2005 in Paris. Among the senior-level participants were 13 chief regulators and 7 heads of research organisations from NEA member countries. Prof. Jukka Laaksonen, CNRA Chairman and Director-

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The NEA Safety and Regulation Forum on Multilateral Co-operation in Nuclear Safety Research and Regulation attracted over 100 participants.

General of STUK, the Radiation and Nuclear Safety Authority of Finland, and Mr. Ashok Thadani, CSNI Chairman and Deputy Executive Director of the Advisory Committees of the United States Nuclear Regulatory Commission, co-chaired the Forum.

Keynote addresses were made by Dr. Nils J. Diaz, Chairman of the US Nuclear Regulatory Commission, on The Next Forty Years, Multinational Design Approval Programme, and Dr. Kazuo Matsunaga, Director-General of Nuclear and Industrial Safety of Japan, on Today's Challenges: Essence of Changes. Dr. Serge Prêtre, Former Director of the Swiss Nuclear Safety Authority, set the scene by presenting Forty Years of Nuclear Safety.

The Forum sessions were: What Have We Learnt; Learning from Each Other – International Approaches; and The Way Forward. Delegates also participated in smaller discussion groups to look more closely at how the safety committees should respond to new information and at ways to improve international harmonisation of nuclear safety practices and approaches. A special discussion group was formed, consisting of experienced committee members and nuclear professionals from the younger generation. This group's goal was to develop an outlook on the future of nuclear safety from different generational viewpoints. Each of the groups derived a number of key findings described in the following paragraphs.

## *Response to new information*

The objective was to explore specific ways in which the committees can respond in a timely manner to their members' needs regarding international regulatory research and sharing regulatory developments. The groups noted that one of the main challenges was to be able to filter numerous sources of information (e.g. from operational events, research results, PSA results, and so forth) to identify significant safety issues and bring them to the attention of the committees. Raising awareness about these potentially significant safety issues and building consensus among regulators and researchers is an important part of the added value of international committees.

In order to achieve this, it is necessary: to have and maintain key research facilities to deal with current and future problems; to improve knowledge management by disseminating and sharing information; to ensure proper project management and long-term planning, including adequate resource allocation; and to base these research programmes on industry needs and safety concerns.

## *International harmonisation*

The main objective in this area was to look at how the committees could contribute, together with other organisations, to furthering the international harmonisation of nuclear safety standards. The groups defined the need to have common technical and legal grounds across markets globally, including a high level of safety principles for both existing and new plants. While the bases for this should be the IAEA Safety Guides, the NEA committees should also use and build upon work currently being performed, such as that by the Western European Nuclear Regulators Association (WENRA). In addition, new initiatives were presented like the Multinational Design Approval Programme (MDAP), that may contribute to convergence of national regulatory practices.

The processes used for reviewing and comparing international safety standards and safety issues help lead to a common safety level among countries. The groups reflected a positive attitude towards future convergence in this area.

## *The younger generation*

The goal of this group was to have a cross-generational discussion on important areas of nuclear safety which will need to be dealt with in the future. The group recognised that up until now, the main issues and decisions relating to nuclear safety have been determined by the older generation. The challenges as well as responsibility concerning nuclear safety in the future will increasingly be managed by the new, younger generation of nuclear experts. It was clear from the discussions that nuclear safety must be guaranteed in competitive electricity markets. It was also noted that new safety requirements to be developed must consider current requirements as a basic premise, in other words, it is not necessary to "reinvent the wheel".

It was also considered important that, in developing new requirements, technical expertise must be valued on every level. As it was pointed out by the group, not everyone can be a manager, but useful results can be derived from all levels of expertise. The group also recommended that the committees strive to obtain more international participation by younger members.

## Celebrating 40 years of co-operation

The Special Session Celebrating 40 Years of Multilateral Exchange in Nuclear Safety at the Nuclear Energy Agency was co-chaired by Prof. Lars Högberg, Former CNRA and NEA Steering Committee Chairman, and Prof. Adolf Birkhofer, former CSNI Chairman. The panel for this session consisted of former members of the CSNI and the CNRA who recalled personal experiences in the nuclear safety area, and the key issues that have been subject to international co-operation in nuclear safety research and regulation.

In particular, the panel looked at how the CSNI and the CNRA had handled these issues, concentrating on what happened and sharing some anecdotes. This included how the committees responded to major events, such as Three Mile Island and Chernobyl, as well as their responses to significant safety concerns (risk assessment, fire protection, international reporting systems) and to the evolution from purely technological issues to those that now concern policy as well. The discussions in this panel also provided a unique opportunity to pass on messages to the younger generation.

## The way forward

While a wide array of insights were obtained by the participants throughout the Forum, the preliminary conclusions focused on four main issues:

- the need to continuously improve operating experience feedback;
- the need to obtain convergence between countries in nuclear safety practices;
- the need to conserve nuclear safety research; and
- the need to ensure good knowledge transfer.

The fact that both the CSNI and the CNRA have been at the forefront of these issues is indicative of their search to meet the needs of member countries and of their accomplishments in this regard. Some examples of what the NEA is doing in these areas, and how, are:

- The CNRA is preparing an overview of regulatory challenges in using operating experience, and an international conference is scheduled to take place in May 2006 in Cologne, Germany to discuss ways to improve nuclear safety through operating experience feedback.
- The NEA is also engaged in ongoing discussions concerning convergence of safety practices in relation to the US Nuclear Regulatory Commission proposal on a Multinational Design Approval Programme (MDAP).
- The CSNI is conducting a new study on safety research and research facilities, aiming to provide the necessary strategy for maintaining key research facilities.
- As a follow-up to past work on maintaining competence, a Workshop on Human Resource Management in Safety and Regulation was organised in October 2005.

While final conclusions still need to be developed, it can already be said that there are higher expectations on the safe use of nuclear energy today than in the past, and that nuclear safety concerns many actors and stakeholders. Listening to them is the new challenge, and many different experts need to be consulted (pluralistic expertise). In doing so, however, essential safety goals cannot be jeopardised as we move into the next 40 years of nuclear safety and regulation. ■

# Over a decade of nuclear emergency management at the NEA

**B. Ahier ***

The OECD Nuclear Energy Agency has a long tradition of expertise in the area of nuclear emergency policy, planning, preparedness and management. Through its activities in this field, the Agency offers its member countries unbiased assistance on nuclear preparedness matters, with a view to facilitating improvements in nuclear emergency preparedness strategies and response at the international level. The 1986 Chernobyl accident demonstrated that nuclear accidents can have international consequences, highlighting the need for international co-operation, and leading to improvements in the areas of international communication, information exchange and harmonisation of response actions between countries.

From its inception, the NEA Working Party on Nuclear Emergency Matters has focused on improving the effectiveness of international nuclear emergency preparedness and management. Part of its work programme is set on exploring and developing new concepts and future procedures to enhance national and international preparedness and response management. A central approach to this has been the preparation and conduct of the International Nuclear Emergency Exercise (INEX) series.

## The role of exercises

The effectiveness of existing nuclear emergency response plans and procedures needs to be regularly tested and proven. In most countries, nuclear emergency exercises, drills and tests are regularly performed at the local, regional and national levels. To explore the international aspects of nuclear accidents, the NEA initiated and established an international nuclear emergency "exercise culture", starting with the 1993 INEX 1 table-top exercise, the first such exercise to be carried out at the international level. This table-top exercise brought together national nuclear emergency response organisations to address a simulated accident at a hypothetical reactor near the border of two fictitious countries. The results of this exercise highlighted the need for more detailed study of international issues, leading to the development of the INEX 2 series.

Conducted between 1996 and 1999 and involving the simultaneous play of over 30 countries and 4 international organisations, the four INEX 2 exercises were built upon pre-planned national level exercises at existing power plants in Switzerland, Finland, Hungary and Canada. The INEX 2 exercises used real national and international emergency response centres, their hardware, procedures and personnel to address in real-time, a simulated accident at a real reactor. In addition to testing existing emergency management arrangements, procedures and communications in real-time, these exercises were intended to investigate processes for decision-making based on limited information, as well as the management of public and media information.

A fifth exercise, INEX 2000, was carried out in 2001, and involved 55 countries and 5 international organisations.

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Similar in scope to INEX 2, this exercise was organised under the auspices of the Inter-agency Committee on Response to Nuclear Accidents. It was designed to test the implementation of concepts and lessons learnt from the INEX 2 series, including the testing of new web-based data management and monitoring strategies, and the co-ordination of media information. This exercise also addressed for the first time, through an international workshop, questions of civil liability following a nuclear emergency.

INEX 2000 was successful in showing that significant improvements in response effectiveness could be achieved through improved data management, and resulted in increased efforts in this area within national emergency preparedness programmes. It also showed that there is still a need to improve efforts to co-ordinate information provided to the media and the public, as conflicting information can cause public confusion and lead to a loss of confidence in decision makers. On a national level, many countries participating in these exercises used the experiences and lessons identified to modify and improve national procedures for nuclear emergency preparedness and management. The INEX data management strategy is now being used in several NEA member countries as well as the international community in general.

Without question, the great majority of exercises conducted by either national authorities or international organisations have focused on the response arrangements for dealing with the early phase of a nuclear emergency. However, within the past few years, and particularly since the 2001 terrorist attacks in the United States, there has been a growing desire among those involved in nuclear emergency management to master more thoroughly response in the later phases following a nuclear or radiological emergency. This can be loosely defined as the period after the crisis phase has passed and radioactive contamination has been released into the environment. The characterisation of contamination deposition may not be fully complete at the beginning of this phase. During this period, agricultural aspects will be increasingly important, and the involvement of stakeholders in decision-making processes will be significant. Evacuees will want to return to their homes, businesses and normal lives; individuals from the affected areas will wish to know with certainty their exposures and risks, and recovery activities will begin. A multitude of practical questions will arise during this period. Policy, structural and procedural aspects of consequence and recovery management must be in place for governments to respond appropriately. Social trust in government and its institutions could well be threatened should responses inadequately address the needs of stakeholders. For this reason, nuclear emergency management specialists are now focusing on identifying the details of the types of issues that will arise, and on developing effective implementation processes and structures for their resolution.

In order to investigate and address these "later-phase" issues, exercises involving consequence and recovery phase management have begun to be organised and conducted. These exercises are helpful in better understanding the nature and the dynamics of the countermeasures to be taken after the early phase, and provide the room for extensive stakeholder involvement. This is true at both the planning stage and during the course of the exercise, due to the fact that decision making in the recovery stage needs to be closely adjusted to the local situation by a deliberation process involving national and local stakeholders.

In response to interest from member countries in later-phase issues arising after an emergency event, the NEA has now developed a third generation of exercises, INEX 3. The INEX 3 table-top exercise focuses on consequence management issues in the medium to late phase following the discovery of serious radiological contamination which may or may not be accidental in nature. Exercise objectives include an investigation of decisions on agricultural countermeasures and food restrictions, countermeasures in other areas such as travel and trade, recovery management and public information. The evaluation will compare national practices and aim to identify "best practice", aspects of national decision making which would benefit from international co-operation, and mechanisms for stakeholder involvement.

Given the table-top format, countries can perform the exercise individually or with neighbouring countries, depending upon strategic national interests. The NEA has developed and made available to interested countries a set of technical materials to assist in the development of their local exercise scenario. INEX 3 has been conducted by about 20 countries during 2005. Following completion of the national exercises, the NEA will host an international evaluation workshop in the spring of 2006 to examine the collective outcomes, lessons and implications raised during these national exercises, and to consider areas for further investigation.

The INEX 3 exercise series has, in specific cases based on national decisions, involved a much broader range of participating organisations and representatives than in previous exercises. This has helped to broaden the scope of stakeholder involvement in emergency management, and to identify issues affecting emergency and post-emergency management that must be resolved through an inclusive emergency management process. As such, it will facilitate the development of mechanisms for incorporating these processes into emergency preparedness and response. Follow-up analyses will focus on issues relevant to managing and recovering from large contamination events, and the role of a broad range of stakeholders in this process, including the investigation of mechanisms for incorporating stakeholder involvement processes into emergency management arrangements.

## Exercise strategies

While international nuclear emergency exercises, such as the new INEX 3 exercise, are crucial for improving the effectiveness of nuclear emergency preparedness and response management, there is a complementary need to address the strategy of emergency exercises from the broader perspective of their role, value and effectiveness within emergency management programmes.

The INEX programme has been built upon the collective experience of its members within their own national emergency preparedness programmes, as well as their emergency response experience. The NEA Working Party on Nuclear Emergency Matters is analysing this experience to develop key strategies for developing and holding national nuclear emergency exercises. This work will provide national emergency management authorities with strategies for their exercise programmes. Such policy-level considerations could include:

- identification of key issues;
- reasons for and objectives of exercises;
- types and frequency of exercises, and links to objectives;
- maximising value and efficiency;
- types and levels of involvement; and
- role of stakeholders in exercise development, conduct and analyses.

It is envisaged that this work will find practical applicability among national and international emergency authorities, providing strategies and insights on exercise justification, design, conduct and evaluation based on the collective experience of the Working Party.

## Future directions

While recognising the major role of emergency exercises within the Working Party activities, this group is now in the process of identifying other specific areas of nuclear emergency management that would benefit from its attention. In addition to the above-mentioned development of strategies for emergency exercises, potential topics could include an analysis of appropriate levels of harmonisation among national approaches, the implementation of lessons learnt in national and international training programmes, "best practices" in nuclear emergency management, decision-making strategies, and mechanisms for stakeholder involvement in emergency management issues.

The NEA Working Party on Nuclear Emergency Matters has developed its exercise series over the past 15 years to facilitate a practical investigation of issues in nuclear emergency management within a unique international context. As the Working Party considers its future programme of work, interest has been expressed in moving towards a full-spectrum understanding of all relevant technical and social issues in emergency management, from response planning to rehabilitation. Collaborative work and joint undertakings between the NEA Committee on Radiation Protection and Public Health and the NEA Nuclear Law Committee will play an important role in ongoing analyses of the link between emergency management decisions and long-term post-accident recovery, including mechanisms for stakeholder involvement. International exercises will continue to provide an important venue for investigating and testing such mechanisms in an interactive and international setting. ■

# Focus on safety: The FIRE Project

**M. Rœwekamp, W. Werner, A. Angner, E. Mathet ***

In 2002, a group of OECD/NEA member countries established the OECD Fire Incident Records Exchange Project (OECD FIRE) to encourage multilateral co-operation in the collection and analysis of data relating to fire events at nuclear power plants. This article presents the OECD Fire Project objectives, work scope and current status, as well as preliminary insights gleaned from the data collected.

Fire hazard analyses (FHAs) and probabilistic safety analyses (PSAs) have shown that fire may be an important contributor to core damage and plant damage states, especially for older nuclear power plants (NPPs). However, realistic modelling of fire scenarios is difficult due to the scarcity of reliable data for fire analysis.

In an attempt to improve the situation, the NEA Committee on the Safety of Nuclear Installations (CSNI) established a task group to review the status and maturity of methods used in fire risk assessment for operating nuclear power plants. The task group issued a questionnaire in May 1997 to all OECD/NEA countries in which nuclear power was being generated. The summary report[1] of this activity was published in March 2000. One of its concluding remarks was as follows: "The shortage of fire analysis data is one of the major deficiencies in present fire risk assessment. In order to facilitate the situation, it would be highly important to establish an international fire analysis data bank, similar to that set up by the OECD for the CCF data collection and processing system... Such a data bank would provide fire event data on real fire cases, pilot fires (smoldering, etc.) detected/extinguished before development, dangerous or threatening situations, reliability data on fire protection measures, and the unavailability of fire fighting systems, for example, due to component failures or operational errors."

Based on the above concluding remarks, several OECD/NEA member countries agreed to establish the International Fire Incident Records Exchange Project (OECD FIRE). Nine countries have signed the project agreement (Czech Republic, Finland, France, Germany, Japan, Spain, Sweden, Switzerland and the United States). As a result, organisations producing or regulating more than 80% of nuclear energy generation worldwide will contribute data to the OECD FIRE Project, which was formally launched in January 2003.

## Objectives of the OECD FIRE Project

The objectives of the OECD FIRE Project include the establishment of a framework for multinational co-operation in fire data collection and analysis. Initially started as a three-year programme (2003-2005), and recently renewed for another three-year mandate, the primary activities of the OECD FIRE Project are to:

- Define a format for collecting fire event experience in a quality-assured and consistent database.
- Collect and analyse fire events over the long term so as to better understand such events, their causes and their prevention.
- Generate qualitative insights into the root causes of fire events, which can then be

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used to derive approaches or mechanisms for their prevention or for mitigating their consequences.

- Establish a mechanism for the efficient feedback of experience gained in connection with fire events including the development of defences against their occurrence, such as indicators for risk-based inspections.
- Record event attributes to facilitate quantification of fire frequencies and fire risk analysis.

The database is planned to be used:

- To support model development, validation and related activities.
- To identify all types of events for inclusion in PSA models to ensure that all mechanisms have been taken into account.
- To evaluate fire occurrence frequencies.

With emphasis on data validity and data quality, an OECD FIRE coding format[2,3] has been developed for collecting and classifying fire event data to ensure consistent interpretations and applications.

## Scope of the OECD FIRE database

The OECD FIRE Project exchanges fire data from commercial nuclear power plants only, but covers all operating modes (including construction and decommissioning phases).

The following criteria have been established for the inclusion of data:

- All fires with a visible open flame (by observation or by consequence) extinguished by manual or automatic measures shall be included if possible.
- Self-extinguished fires are to be included if they have caused significant damage. If the self-extinguished fire affected only one component, the event can be excluded.
- Explosions not resulting in an open flame are not within the scope of the database.

One challenge in setting up an international database is to ensure a consistent reporting level between countries in order to capture all events fulfilling the objectives of the project. Regulatory bodies' and utilities' reporting levels vary between member countries (e.g., absence or presence of an affect on safety equipment, different duration thresholds, etc.), and, in addition, these levels may have evolved over time. For events prior to 2003, the database includes for reference the evolution of reporting levels over time. For events post-2003, one objective of the first phase has been to define a project reporting level, which would account for the countries' policies while correctly addressing the technical objectives of the project.

Currently, the database contains 120 fire events, most of them quality-assured. The events date from the early 1980s to 2004, with the bulk of the events situated between the mid-1990s and 2004. Although the reporting of events is not exhaustive, the database provides a good platform from which to begin analysis. It is expected that 40 to 50 events will continue to be reported per year. In the table below, estimates are provided of the number of fire events theoretically available to the project. The figures represent the number of fires expected per year in operating reactors in OECD FIRE Project member countries (260 reactors).

The table presents the estimated number of fires for power operation mode and non-power operation mode. During power operation mode it can be expected that approximately 5 out of 30 fires will result in reactor shutdown. A total of 12 out of the 30 fires are expected to require fire brigade intervention. It can also be understood that the relative frequency of fires during non-power operation is much higher than during power operation.

## The OECD FIRE database structure

The OECD FIRE event is described by the narrative event description and a number of description fields with attributes to be selected from predefined menus. The source of information is normally the narrative event description; the entries in the description

**Estimated numbers of fire events per year**

| | |
|---|---|
| Power operation | |
| Events resulting in reactor shutdown | 5/y |
| Events requiring fire brigade intervention | 12/y |
| All events | 30/y |
| Non-power operation | |
| Events requiring fire brigade intervention | 8/y |
| All events | 16/y |

fields are derived from the narrative event description. Coding can also be based on documented references.

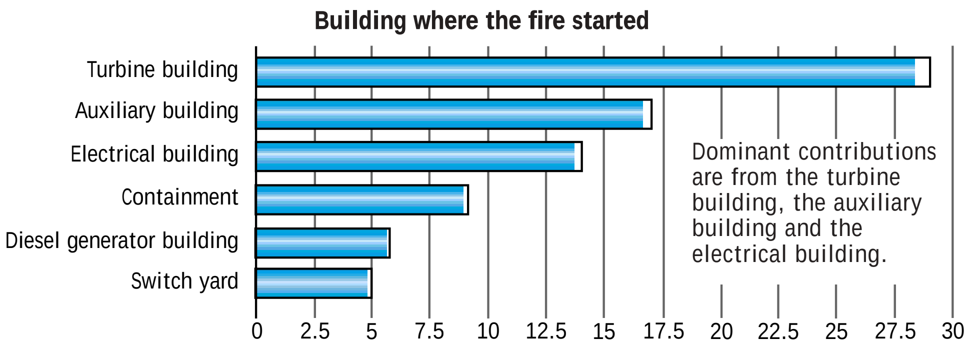
The classifications of the fire event through coded attributes provide the possibility to search for and identify specific fire events of interest in the OECD FIRE database for a wide range of applications. The bulk of the information requested in the narratives is compulsory information. However, there is also optional information, such as the amount of fire load, which is time-consuming to collect. This type of information is marked as "if available". This information can be collected at a later stage, if necessary, for a limited number of events.

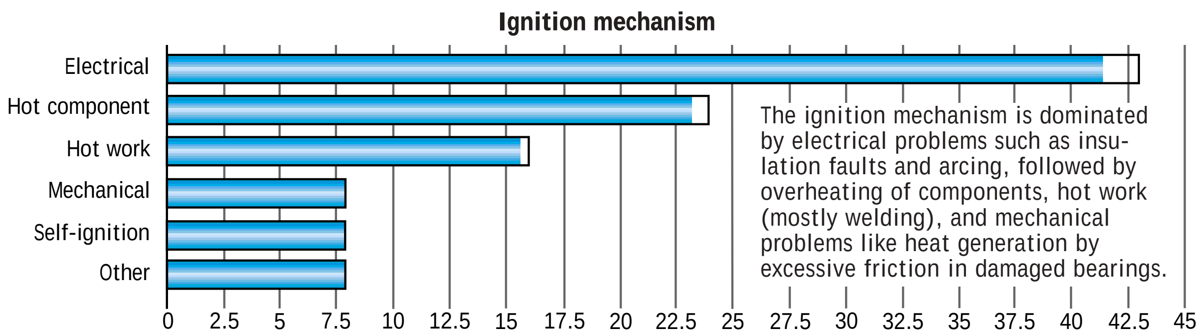
The database is divided into the following major parts:

1. *Narrative event description*: The narratives begin with a short description or title of the event, followed by a detailed factual description of the fire event, including relevant circumstances.
2. *Sequence of events*: This narrative is a structured record of the event in the form of a bullet list with the time and description of the event. The reader should be able to understand how the event developed over time.
3. *Ignition phase*: This describes (by use of codes) the initial course of the fire, including items such as location of the fire, type of detection, fire loads, ignition mechanism and root cause.
4. *Extinguishing phase*: This section describes (by use of codes) the course of the event after the fire alarm was triggered (type of extinguishing equipment used, who extinguished the fire).
5. *Consequences*: The heat and smoke influence on plant operation and systems are described (by use of codes). Secondary effects and corrective actions are included.
6. *References*: These include the references used, and where to find more information on the specific fire event.

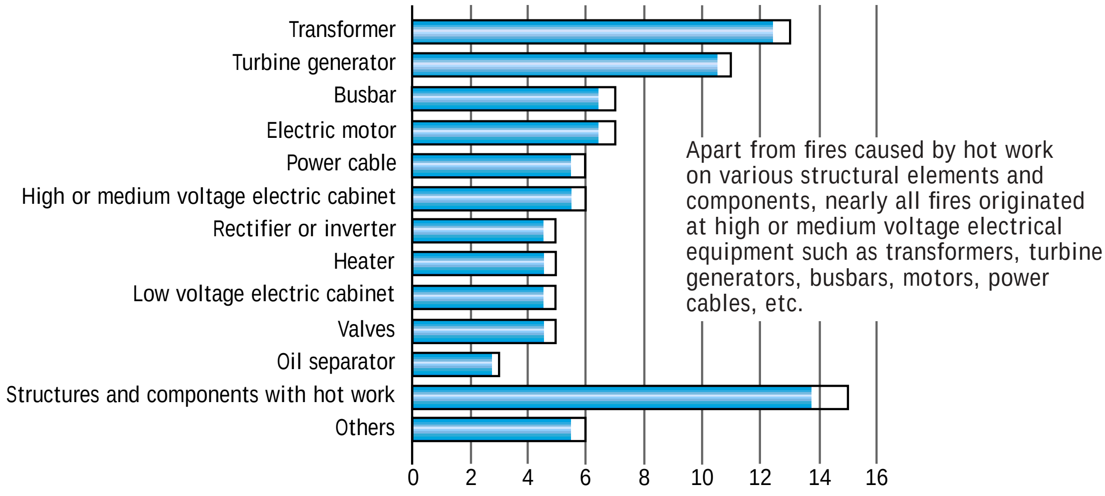
## Statistical observations

A selection of basic statistical information on fire-relevant issues is presented below. On the ordinate of each chart are listed the attributes that turned out to be important for the issue considered. The number of occurrences of the selected attributes are shown on the abscissa. The statistics presented are not exhaustive; i.e. only significant contributors to the various issues are displayed.

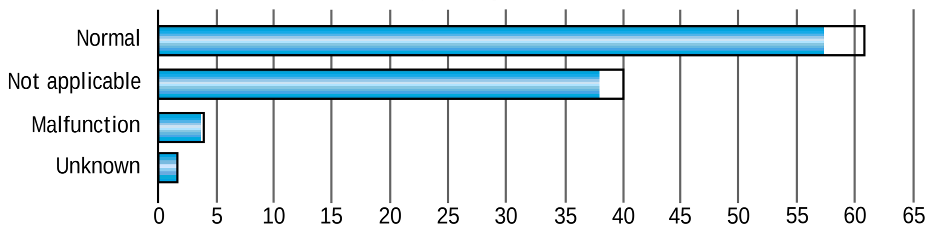


## Component where the fire started




## Detection system performance




The “Not applicable” reporting frequency is relatively high. This results mainly from situations of fires detected early and subsequently extinguished quickly by plant personnel available in the fire area, and fires at locations without detectors, for example outside buildings. Excluding the "Not applicable" cases, the detection systems are considered to have performed normally in almost all real-demand situations.

## Conclusions

The number of collected reports is still too small to make corroborated statistical inferences. However, some general observations can already be made:

- Most of the fires originated at electrical equipment. The share of fires caused by hot work is also significant.
- Detection systems functioned as designed in almost all real-demand situations.
- More than 80% of the fires were successfully dealt with by manual fire fighting or by a combination of manual fire fighting and fixed system actions. The remaining ones were self-extinguished.
- No complete malfunction of fire extinguishing systems was reported. However, cases have been reported where several means of fire fighting had to be used before success was achieved.
- Few cases were reported which required the involvement of the external fire brigade to extinguish the fire.
- 14% of the events led to plant shutdown.

## References

1. NEA/CSNI/R(99)27, *Fire risk analysis, fire simulation, fire spreading and impact of smoke and heat on instrumentation electronics*, 10 March 2000.
2. OECD FIRE Report PR05, *OECD FIRE Quality Assurance Program*, Final report 2003-04-28.
3. OECD FIRE Report PR02, *OECD FIRE General Coding Guidelines*, Version 4, 2003-09-19.

# NEA joint projects

NEA joint projects and information exchange programmes enable interested countries, on a cost-sharing basis, to pursue research or the sharing of data with respect to particular areas or problems. The projects are carried out under the auspices,

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|---|---|---|
| **Cabri Water Loop Project**<br>Contact: carlo.vitanza@oecd.org<br>Current mandate: 2000-2010 | Czech Republic, Finland, France, Germany, Hungary, Korea, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States | ≈US$ 7.75 million/year |
| **COMPSIS Project**<br>Contact: pekka.pyy@oecd.org<br>Current mandate: January 2005-December 2007 | Chinese Taipei, Finland, Germany, Hungary, Japan, Korea, Slovak Republic, Sweden, Switzerland, United States | € 100 000 /year |
| **Co-operative Programme on Decommissioning (CPD)**<br>Contact: torsten.eng@oecd.org<br>Current mandate: January 2004-January 2009 | Belgium, Canada, Chinese Taipei, France, Germany, Italy, Japan, Korea, Slovak Republic, Spain, Sweden, United Kingdom | ≈US$ 45 000 /year |
| **Fire Incidents Records Exchange (FIRE) Project**<br>Contact: jean.gauvain@oecd.org<br>Current mandate: January 2003-December 2005, renewed for the 2006-2008 period | Canada, Czech Republic, Finland, France, Germany, Japan, Netherlands, Spain, Sweden, Switzerland, United States | ≈€ 74 700 /year |
| **Halden Reactor Project**<br>Contacts: pekka.pyy@oecd.org<br>carlo.vitanza@oecd.org<br>Halden contact: Fridtjov.owre@hrp.no<br>Current mandate: January 2003-December 2005, renewed for the 2006-2008 period | Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Japan, Korea, Norway, Russia, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States | ≈US$ 17 million/year |
| **Information System on Occupational Exposure (ISOE Programme)**<br>Contact: brian.ahier@oecd.org<br>Current mandate: 2002-2007 | Armenia, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Korea, Lithuania, Mexico, Netherlands, Pakistan, Romania, Russia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States | ≈US$ 445 000 /year |
| **International Common-cause Data Exchange (ICDE) Project**<br>Contact: pekka.pyy@oecd.org<br>Current mandate: April 2005-March 2008 | Canada, Finland, France, Germany, Japan, Korea, Spain, Sweden, Switzerland, United Kingdom, United States | ≈US$ 150 000 /year |

and with the support, of the NEA. Such projects, primarily in the areas of nuclear safety and radioactive waste management, are one of the NEA's major strengths. All NEA joint projects currently under way are listed below.

| |
|---|
| • Extend the database for high burn-up fuel performance in reactivity-induced accident (RIA) conditions.<br>• Perform relevant tests under coolant conditions representative of pressurised water reactors (PWRs). |
| • Define a format and collect software and hardware fault experience in computer-based, safety-critical NPP systems in a structured, quality-assured and consistent database.<br>• Collect and analyse COMPSIS events over a long period so as to better understand such events, their causes and their prevention.<br>• Generate insights into the root causes of and contributors to COMPSIS events, which can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences.<br>• Establish a mechanism for efficient feedback of experience gained in connection with COMPSIS events, including the development of defences against their occurrence, such as diagnostics, tests and inspections.<br>• Record event attributes and dominant contributors so that a basis for national risk analysis of computerised systems is established. |
| • Exchange scientific and technical information amongst decommissioning projects on nuclear facilities. |
| • Collect fire event experience (by international exchange) in the appropriate format and in a quality-assured and consistent database.<br>• Collect and analyse fire events data over the long term with the aim to better understand such events, their causes and their prevention.<br>• Generate qualitative insights into the root causes of fire events which can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences.<br>• Establish a mechanism for the efficient feedback of experience gained in connection with fire including the development of defences against their occurrence, such as indicators for risk-based inspections.<br>• Record characteristics of fire events in order to facilitate fire risk analysis, including quantification of fire frequencies. |
| Generate key information for safety and licensing assessments and aim at providing:<br>• extended fuel utilisation: basic data on how the fuel performs, both at normal operation and transient conditions, with emphasis on extended fuel utilisation in commercial reactors;<br>• degradation of core materials: knowledge of plant materials behaviour under the combined deteriorating effects of water chemistry and nuclear environment, also relevant for plant lifetime assessments;<br>• man-machine systems: advances in computerised surveillance systems, virtual reality, digital information, human factors and man-machine interaction in support of upgraded control rooms.<br>These activities are collectively known as "The Joint Programme". |
| • Collect and analyse occupational exposure data and experience from all participants to form the ISOE databases.<br>• Provide broad and regularly updated information on methods to improve the protection of workers and on occupational exposure in nuclear power plants.<br>• Provide a mechanism for dissemination of information on these issues, including evaluation and analysis of the data assembled, as a contribution to the optimisation of radiation protection. |
| • Provide a framework for multinational co-operation.<br>• Collect and analyse common-cause failure (CCF) events over the long term so as to better understand such events, their causes and their prevention.<br>• Generate qualitative insights into the root causes of CCF events which can then be used to derive approaches or mechanisms for their prevention or for mitigating their consequences.<br>• Establish a mechanism for the efficient feedback of experience gained in connection with CCF phenomena, including the development of defences against their occurrence, such as indicators for risk-based inspections.<br>• Record event attributes for quantification of CCF frequency. |

| | | |
|---|---|---|
| **MASCA-2 (Material Scaling) Project**<br>Contact: jean.gauvain@oecd.org<br>Current mandate: June 2003-June 2006 | Belgium, Canada, Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, Russia, Slovak Republic, Spain, Sweden, Switzerland, United States | ≈US$ 1 million/year |
| **Melt Coolability and Concrete Interaction (MCCI) Project**<br>Contact: carlo.vitanza@oecd.org<br>Current mandate: January 2002-December 2005 | Belgium, Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, Norway, Spain, Sweden, Switzerland, United States | ≈US$ 1.2 million/year |
| **Piping Failure Data Exchange (OPDE) Project**<br>Contact: jean.gauvain@oecd.org<br>Current mandate: July 2005-July 2008 | Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Korea, Spain, Sweden, Switzerland, United States | ≈US$ 72 000 /year |
| **PKL-2 Project**<br>Contact: miroslav.hrehor@oecd.org<br>Current mandate: January 2004-December 2006 | Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Korea, Spain, Sweden, Switzerland, United Kingdom, United States | US$ 1.2 million/year |
| **PSB-VVER Project**<br>Contact: miroslav.hrehor@oecd.org<br>Current mandate: February 2003-December 2006 | Czech Republic, Finland, France, Germany, Italy, Russia, United States | US$ 0.4 million/year |
| **Rig of Safety Assessment (ROSA) Project**<br>Contact: miroslav.hrehor@oecd.org<br>Current mandate: April 2005-December 2009 | Belgium, Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, Spain, Sweden, Switzerland, United Kingdom, United States | US$ 1 million/year |
| **Studsvik Cladding Integrity Project (SCIP)**<br>Contact: carlo.vitanza@oecd.org<br>Current mandate: July 2004-June 2009 | Czech Republic, Finland, France, Germany, Japan, Korea, Spain, Sweden, Switzerland, United Kingdom, United States | ≈US$ 1.6 million/year |
| **SETH (SESAR Thermal-hydraulics) Project**<br>Contact: miroslav.hrehor@oecd.org<br>Current mandate: April 2001-June 2006 | Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States | US$ 0.9 million/year |
| **Thermochemical Database (TDB) Project**<br>Contact: federico.mompean@oecd.org<br>Current mandate: February 2003-February 2007 | Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Spain, Sweden, Switzerland, United Kingdom, United States | ≈€ 0.4 million/year |

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| • Provide experimental information on the phase equilibrium for different corium mixture compositions that can occur in water reactors.<br>• Generate data on relevant physical properties of mixtures and alloys that are important for the development of qualified mechanistic models. |
| • Provide experimental data on melt coolability and concrete interaction (MCCI) severe accident phenomena.<br>• Resolve two important accident management issues:<br>– the verification that molten debris that has spread on the base of the containment can be stabilised and cooled by water flooding from the top;<br>– the two-dimensional, long-term interaction of the molten mass with the concrete structure of the containment, as the kinetics of such interaction is essential for assessing the consequences of a severe accident. |
| • Collect and analyse piping failure event data to promote a better understanding of underlying causes, impact on operations and safety, and prevention.<br>• Generate qualitative insights into the root causes of piping failure events.<br>• Establish a mechanism for efficient feedback of experience gained in connection with piping failure phenomena, including the development of defence against their occurrence.<br>• Collect information on piping reliability attributes and influence factors to facilitate estimation of piping failure frequencies, when so decided by the Project Review Group. |
| • Investigate pressurised water reactor (PWR) safety issues by means of thermal-hydraulic experiments to be conducted at the *Primärkreislauf-Versuchsanlage* (primary coolant loop test facility) in Germany.<br>• One category of tests focuses on boron-dilution issues.<br>• A second type of test addresses potential accident conditions during shutdown (mid-loop operation). |
| • Provide the unique experimental data needed for the validation of thermal-hydraulic codes and to support refinements to safety assessment tools for VVER-1000 reactors. |
| • Provide an integral and separate-effect experimental database to validate code predictive capability and accuracy of models. In particular, phenomena coupled with multi-dimensional mixing, stratification, parallel flows, oscillatory flows and non-condensable gas flows are to be studied.<br>• Clarify the predictability of codes currently used for thermal-hydraulic safety analyses as well as of advanced codes presently under development, thus creating a group among OECD member countries who share the need to maintain or improve technical competence in thermal-hydraulics for nuclear reactor safety evaluations. |
| • Assess material properties and determine conditions that can lead to fuel failures.<br>• Improve the general understanding of cladding reliability at high burn-up through advanced studies of phenomena and processes that can impair fuel integrity during operation in power plants and during handling or storage.<br>• Achieve results of general applicability (i.e. not restricted to a particular fuel design, fabrication specification or operating condition). |
| • Carry out thermal-hydraulic experiments in support of accident management at facilities identified by the NEA Committee on the Safety of Nuclear Installations (CSNI), such as those requiring international collaboration to sponsor their continued operation.<br>• The first part of the programme addressing primary loop accidents has been completed.<br>• The second part addressing data for computerised fluid dynamics (CFD) code validation for containment applications is under way. |
| Produce a database that:<br>• contains data for all the elements of interest for radioactive waste disposal systems;<br>• documents why and how the data were selected;<br>• gives recommendations based on original experimental data, rather than on compilations and estimates;<br>• documents the sources of experimental data used;<br>• is internally consistent;<br>• treats all solids and aqueous species of the elements of interest for nuclear waste storage performance assessment calculations. |

# Legislative updates

## **Finland:** *Nuclear Liability Bill (2005)*

The Nuclear Liability Bill was passed by the Finnish Parliament in early June 2005 and was enacted by the President a few weeks later. The purpose of this Bill, which will enter into force at a later date as determined by Government Decree, is to amend the 1972 Nuclear Liability Act to incorporate the following changes:

- Finnish nuclear operators will require insurance coverage for a minimum amount of EUR 700 million; the liability of Finnish operators shall be unlimited in instances where the Brussels Supplementary Convention (an international pooling system providing cover up to EUR 1.5 billion) has been exhausted and there remains damage to be compensated.
- The Finnish Council of State may decide on a lower amount of liability with regard to the transport of nuclear substances; however this amount may not be less than EUR 80 million. No other reduced liability amounts shall be applicable.
- Nuclear damage shall be defined as per the amended Article 1 of the revised Paris Convention, covering a broader range of damage than the existing personal injury and damage to property: the definition refers specifically to economic loss, the cost of measures to reinstate a significantly impaired environment, loss of income resulting from that impaired environment and the cost of preventive measures.
- Nuclear damage caused by acts of terrorism shall be covered by this legislation. ■

## **United States:** *Price-Anderson Act Renewal (2005)*

On 8 August 2005, President Bush signed into law the Energy Policy Act of 2005, marking the end of a four-year effort to forge an agreement on this national energy plan. The Act incorporates a wide range of measures supporting today's operating nuclear plants, providing incentives for building new nuclear plants, offering risk protection for companies pursuing the construction of new reactors and strengthening the Energy Department's nuclear energy programmes. Title VI of the Energy Policy Act renews the Price-Anderson Act governing nuclear third party liability and insurance in the United States.

The 1957 Price-Anderson Act established a federal regime for handling the consequences of nuclear accidents in the United States. At its inception, the Act provided USD 560 million of nuclear liability coverage for nuclear power plants and certain other nuclear facilities. Today, this coverage amounts to approximately USD 10.7 billion for the 103 nuclear power plants in the United States. This regime places jurisdiction over cases involving nuclear incidents in federal courts, but leaves the matter of determining liability to the substantive laws of the individual states, as in other tort cases. The Price-Anderson Act creates a system of "omnibus" coverage for "anyone liable" for a nuclear incident, a form of economic channelling as opposed to the legal channelling of liability to the nuclear operator established by the Vienna and Paris Convention regimes.

Each nuclear operator provides nuclear coverage for anyone liable through a combination of private insurance from the US nuclear insurance pool (primary financial protection – USD 300 million) and a retrospective assessment (secondary financial protection - until now, USD 95.8 million per power plant per incident plus 5% for claims and costs, payable in annual installments up to a maximum of USD 10 million per power plant per incident). Payments are guaranteed by the US Government and an inflation adjustment is made every five years. Originally, the Price-Anderson Act was administered by the US Atomic Energy Commission (USAEC) for both commercial and US Government nuclear activities. When the USAEC was abolished in 1974, Price-Anderson responsibility was allocated between two separate agencies: the US Nuclear Regulatory Commission (USNRC) administers Price-Anderson coverage for its licensees, while the US Department of Energy (USDOE) administers coverage for its contractors. USDOE contractors are indemnified by the US Government in the same amount as for nuclear power plants.

The new Energy Policy Act of 2005 includes the Price-Anderson Amendments Act of 2005 (Sections 601 to 610). The 2005 Amendments extend the Price-Anderson authority of the USNRC another 20 years to 31 December 2025. This essentially applies to new nuclear power plants, since coverage for all existing NPPs was established under the original Act. The main change for existing and future NPPs is that the annual maximum retrospective assessment per reactor per nuclear incident has been increased from USD 10 million to USD 15 million (with inflation indexing every five years). The 2005 Amendments also provide that modular power reactors of 100 MW or more (e.g. pebble bed units) will be treated as one unit for the assessments. The current total amount of coverage and liability limit for NPPs (USD 10.7 billion) remains the same. The Amendments also extend to 31 December 2025 the separate authority of the USDOE to indemnify its contractors for nuclear hazards. ■

# New publications

## Economic and technical aspects of the nuclear fuel cycle

### Actinide and Fission Product Partitioning and Transmutation

#### Eighth Information Exchange Meeting Las Vegas, Nevada, United States 9-11 November 2004

*ISBN 92-64-01071-8* *Free: paper or web.*

In response to the interest expressed by its member countries, the OECD Nuclear Energy Agency (NEA) has regularly organised biennial information exchange meetings on actinide and fission product partitioning and transmutation (P&T) since 1990, in order to provide experts with a forum to present and discuss the latest developments in the field. This book and its enclosed CD-ROM contain the proceedings of the 8th Information Exchange Meeting held in Las Vegas, Nevada, USA on 9-11 November 2004. The meeting covered the broad spectrum of developments in the field, including the potential impact of P&T on radioactive waste management, new partitioning technologies, fuels for transmutation devices, as well as critical and accelerator-driven transmuting devices. More than 80 papers were presented during the meeting and have been reproduced in the proceedings.

# Nuclear safety and regulation

## Review of the Role, Activities and Working Methods of the CNRA

### Committee on Nuclear Regulatory Activities (CNRA)

*ISBN 92-64-01062-9 Free: paper or web.*

This report, prepared by an independent review group, characterises the current role, priorities and working methods of the NEA Committee on Nuclear Regulatory Activities (CNRA), identifies and analyses issues of concern, and suggests ways to further increase the efficiency and effectiveness as well as the visibility of the committee. It also reviews the role and interactions between the CNRA and the other NEA standing technical committees and international organisations, and suggests ways to improve co-ordination and co-operation. In formulating its report, the review group examined various CNRA documents (e.g. summary records, reports) interviewed past and present CNRA members, standing technical committee chairs and others, and gathered additional input through a questionnaire. Conclusions and recommendations have been derived concerning the mid-term and long-term role and orientation of the committee and, in particular, the balance between technical- and policy-related activities.

## The Safety of the Nuclear Fuel Cycle

*ISBN 92-64-01421-7 Price: € 70, US$ 88, £ 48, ¥ 9600.*

The procurement and preparation of fuel for nuclear power reactors, followed by its recovery, processing and management subsequent to reactor discharge, are frequently referred to as the "front end" and "back end" of the nuclear fuel cycle. The facilities associated with these activities have an extensive and well-documented safety record accumulated over the past 50 years by technical experts and safety authorities. This information has enabled an in-depth analysis of the complete fuel cycle. Preceded by two previous editions in 1981 and 1993, this new edition of the Safety of the Nuclear Fuel Cycle represents the most up-to-date analysis of the safety aspects of the nuclear fuel cycle. It will be of considerable interest to nuclear safety experts, but also to those wishing to acquire extensive information about the fuel cycle more generally.

## Review of the Role, Activities and Working Methods of the CSNI

### Committee on the Safety of Nuclear Installations (CSNI)

*ISBN 92-64-01072-6 Free: paper or web.*

This report, prepared by a senior-level assessment group, describes the current role, priorities and working methods of the NEA Committee on the Safety of Nuclear Installations (CSNI), identifies and analyses issues of concern, and suggests ways to further increase the efficiency and effectiveness of the committee. It also reviews CSNI interactions with the NEA Committee on Nuclear Regulatory Activities (CNRA), the other NEA standing technical committees and international organisations, and suggests ways to improve co-ordination and co-operation. In closing, conclusions are drawn and recommendations made concerning the future operation and role of the committee.

# Radiological protection

## Evolution of the System of Radiological Protection

### Second Asian Regional Conference, Tokyo, Japan, 28-29 July 2004

*ISBN 92-64-01362-8 Price: € 40, US$ 50, £ 27, ¥ 5 500.*

One of the main challenges facing radiological protection experts is how to integrate radiological protection within modern concepts of and approaches to risk governance. It is within this context that the International Commission on Radiological Protection (ICRP) decided to develop new general recommendations to replace its *Publication 60* recommendations of 1990. In the process of developing these new recommendations, the views of the ICRP have evolved significantly, largely due to stakeholder involvement that has been actively solicited by the ICRP. In this regard, it was upheld during the First Asian Regional Conference organised by the NEA in October 2002 that the implementation of the new system must allow for regional, societal and cultural differences. In order to ensure appropriate consideration of these differences, the NEA organised the Second Asian Regional Conference on the Evolution of the System of Radiological Protection. Held in Tokyo on 28-29 July 2004, the conference included presentations by the ICRP Chair as well as by radiological experts from Australia, China, Japan and Korea. Within their specific cultural and socio-political milieu, Asia-Pacific and western ways of thought on how to improve the current system of radiological protection were presented and discussed. These ways of thinking, along with a summary of the conference results, are described in these proceedings.

## Occupational Exposure Management at Nuclear Power Plants

### Fourth ISOE European Symposium, Lyon, France 24-26 March 2004

*ISBN 92-64-01036-X Price: € 50, US$ 65, £ 34, ¥ 6700.*

The Information System on Occupational Exposure (ISOE) has become a unique, worldwide programme on the protection of workers at nuclear power plants. It includes a vast network for exchanging experience in the area of occupational exposure management as well as the world's largest database on occupational exposure from nuclear power plants. Each year, an ISOE international symposium offers a forum for radiation protection professionals from the nuclear industry, operating organisations and regulatory authorities to exchange information on practical experience with occupational radiation exposure issues in nuclear power plants. These proceedings summarise the presentations made at the Fourth ISOE European Symposium on Occupational Exposure Management at Nuclear Power Plants, held in March 2004 in Lyon, France.

## Occupational Exposures at Nuclear Power Plants – 2003

### Thirteenth Annual Report on the ISOE Programme, 2003

*ISBN 92-64-01065-3 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% of the world's total operating commercial reactors).The Thirteenth Annual Report of the ISOE Programme summarises achievements made during 2003 and compares annual occupational exposure data. Principal developments in ISOE participating countries are also described.

# Radioactive waste management

## Achieving the Goals of the Decommissioning Safety Case

### A Status Report

*ISBN 92-64-01068-8 Free: paper or web.*

The key issue in the decommissioning of nuclear facilities is the progressive removal of hazards, by stepwise decontamination and dismantling activities that have to be carried out safely and within the boundaries of an approved safety case. The decommissioning safety case is a collection of arguments and evidence to demonstrate the safety of a decommissioning project. The safety case involved analysing the hazards and the separate stages required for hazard reduction. This status report, drawn from the activities of the OECD/NEA Working Party on Decommissioning and Dismantling (WPDD), will be helpful to individuals and organisations involved in the preparation of a decommissioning safety case.

## Clay Club Catalogue of Characteristics of Argillaceous Rocks

*ISBN 92-64-01067-X Free: paper or web.*

The OECD/NEA Working Group on the Characterisation, the Understanding and the Performance of Argillaceous Rocks as Repository Host Formations, namely the "Clay Club", examines the various argillaceous rocks that are being considered for the deep geological disposal of radioactive waste, i.e. from plastic, soft, poorly indurated clays to brittle, hard mudstones or shales. The Clay Club considered it necessary and timely to provide a catalogue to gather in a structured way the key geoscientific characteristics of the various argillaceous formations that are – or were – studied in NEA member countries with regard to radioactive waste disposal. The present catalogue represents the outcomes of this Clay Club initiative.

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

### Process Issues – Workshop Proceedings, Las Vegas, United States, 14-17 September 2004

*ISBN 92-64-01313-X Price: € 40, US$ 50, £ 27, ¥ 5 500.*

The Integration Group for the Safety Case (IGSC) of the Nuclear Energy Agency (NEA) is co-sponsoring a project with the European Commission to develop a greater understanding of how to achieve the necessary integration for successful design, construction, testing, modelling and performance assessment of engineered barrier systems (EBS). These proceedings include the main findings and presented papers from the second workshop of the EC-NEA EBS project, which covered *inter alia* research and development work on pre- and post-closure processes; thermal management; thermal, hydraulic, mechanical and chemical process models; and repository design. The workshop was hosted by the US Department of Energy in Las Vegas, USA, on 14-17 September 2004.

## International Peer Reviews for Radioactive Waste Management

### General Information and Guidelines

*Bilingual*

*ISBN 92-64-01077-7 Free: paper or web.*

International peer reviews as a working method is closely associated with OECD practice, where it is facilitated by the homogeneous membership and the high degree of trust shared by the member countries. International peer reviews of national radioactive waste management programmes, or of specific aspects of them, have been increasingly carried out over the past ten years. This document lays down the guidelines that the requesting country, the Secretariat and the international review team ought to have in mind when an international peer review is requested, organised or carried out.

## NEA Sorption Project Phase II

### Interpretation and Prediction of Radionuclide Sorption onto Substrates Relevant for Radioactive Waste Disposal Using Thermodynamic Sorption Models

*ISBN 92-64-01206-0 Price: €70, US$ 88, £ 48, ¥ 9 600.*

The modelling of the key process of radionuclide sorption is of great importance in assessing the performance or safety of deep and near-surface repositories for radioactive waste. The first phase of the NEA Sorption Project ran from 1997 to 1998, and highlighted the diversity in the details of the thermodynamic descriptions of sorption processes. Phase II of the NEA Sorption Project was initiated as a major international contribution towards demonstrating the consistency and applicability of different thermodynamic sorption models to support the selection of a sorption parameter, namely Kd values for safety assessments. It was implemented in the form of a comparative modelling exercise based on selected datasets for radionuclide sorption by both simple and complex materials. This report presents the results of Phase II of the Sorption Project, conducted as a co-operative project under the auspices of the Integration Group for the Safety Case (IGSC) of the OECD/NEA Radioactive Waste Management Committee (RWMC).

## Radioactive Waste Management Programmes in OECD/NEA Member Countries

*ISBN 92-64-01210-9 Price: € 45, US$ 56, £ 31, ¥ 6 200.*

These fact sheets present the radioactive waste management programmes of 20 OECD/NEA member countries. They include information about the sources, types and quantities of waste as well as how and by whom they are managed. References for further information are also provided for each country.

## The Regulatory Function and Radioactive Waste Management

### International Overview

*ISBN 92-64-01075-0 Free: paper or web.*

This overview presents an easily accessible synopsis of the regulatory control of radioactive waste management in 15 NEA member countries. It covers the management of radioactive waste from all types of nuclear installations, such as nuclear power plants, research reactors and nuclear fuel cycle facilities. It also addresses medical, research and industrial sources as well as defence-related sources where relevant. The overview should be of interest to a wide audience of both specialists and non-specialists.

# Nuclear Law

## Nuclear Law Bulletin Nos. 75 and 76

*ISSN 0304-341X Price: € 90, US$ 103, £ 58, ¥ 12 200.*

Considered to be the standard reference work for both professionals and academics in the field of nuclear law, the *Nuclear Law Bulletin* is a unique international publication providing its subscribers with up-to-date information on all major developments falling within the domain of nuclear law. Published twice a year in both English and French, it covers legislative developments in almost 60 countries around the world as well as reporting on relevant jurisprudence and administrative decisions, international agreements and regulatory activities of international organisations.

## + Supplement to Nuclear Law Bulletin

### No. 75 – Unofficial Consolidated Texts of the Paris and Brussels Supplementary Conventions as Amended

*ISBN 92-64-01214-1 Price: € 24, US$ 29, £ 16, ¥ 3 200.*

### No. 76 – Estonia 2004 Radiation Act

*ISBN 92-64-03674-1 Price: € 24, US$ 29, £ 16, ¥ 3 300.*

# Nuclear Science and the Data Bank

## Benchmark on Deterministic Transport Calculations Without Spatial Homogenisation

### MOX Fuel Assembly 3-D Extension Case

*ISBN 92-64-01069-6 Free: paper or web.*

An important issue regarding deterministic transport methods for whole core calculations is that homogenised techniques can introduce errors into results. In addition, with modern computational abilities, direct whole core heterogeneous calculations are becoming increasingly feasible. Following a previous benchmark in this series in 2003, this 3-D extension case was designed to simulate three core configurations with different levels of axial heterogeneity utilising control rods. A majority of the participants obtained solutions that were more than acceptable for typical nuclear reactor calculations, showing that modern deterministic transport codes and methods can calculate the flux distribution reasonably well without relying upon special homogenisation techniques. The report will be of particular interest to reactor physicists and transport code developers.

## Boiling Water Reactor Turbine Trip (TT) Benchmark - Volume II

### Summary Results of Exercise 1

*ISBN 92-64-01064-5 Free: paper or web.*

In the field of coupled neutronics/thermal-hydraulics computation there is a need to enhance scientific knowledge in order to develop advanced modelling techniques for new nuclear technologies and concepts as well as for current applications. Recently developed "best-estimate" computer code systems for modelling 3-D coupled neutronics/thermal-hydraulics transients in nuclear cores and for coupling core phenomena and system dynamics (PWR, BWR, VVER) need to be compared against each other and validated against results from experiments. International benchmark studies have been set up for this purpose. The present report is the second in a series of four and summarises the results of the first benchmark exercise, which identifies the key parameters and important issues concerning the thermal-hydraulic system modelling of the transient, with specified core average axial power distribution and fission power time transient history. The transient addressed is a turbine trip in a boiling water reactor, involving pressurisation events in which the coupling between core phenomena and system dynamics plays an important role. In addition, the data made available from experiments carried out at the Peach Bottom 2 reactor (a GE-designed BWR/4) make the present benchmark particularly valuable.

## Evaluation of Proposed Integral Critical Experiments with Low-moderated MOX Fuel

*ISBN 92-64-01049-1 Free: paper or web.*

Athough the fabrication of mixed-oxide (MOX) fuel is well-established with appropriate safety margins, it would still be beneficial to optimise the process by further investigating and possibly reducing these margins. It is also important to demonstrate that all operations involving plutonium and MOX fuels adhere to strict safety standards, and that these standards are based upon the most reliable tools and data. An NEA workshop, organised in April 2004, confirmed that even though existing unpublished experiments could partially address the need for more accurate experimental data, the need for additional experiments remained. An ad hoc expert group was therefore established to define a framework and method for the selection and performance of new experimental programme(s) of interest. The present publication describes the selection criteria and methodology that were used to compare experimental proposals and makes recommendations on which experimental programme(s) should be pursued.

## International Evaluation Co-operation – Vol. 19

### Neutron Activation Cross-section Measurements from Threshold to 20 MeV for the Validation of Nuclear Models and their Parameters

*ISBN 92-64-01070-X* *Free: paper or web.*

A Working Party on International Evaluation Co-operation was established under the sponsorship of the OECD/NEA Nuclear Science Committee (NSC) to promote the exchange of information on nuclear data evaluations, validation and related topics. Its aim is also to provide a framework for co-operative activities among the members of the major nuclear data evaluation projects. This includes the possible exchange of scientists in order to encourage co-operation. The working party compiles requirements for experimental data resulting from these activities and determines common criteria for evaluated nuclear data files with a view to assesssing and improving the quality and completeness of evaluated data.

## International Evaluation Co-operation – Vol. 21

### Assessment of Neutron Cross-section Evaluations for the Bulk of Fission Products

*ISBN 92-64-01063-7* *Free: paper or web.*

Subgroup 21 of the NEA Nuclear Science Committee Working Party on International Evaluation Co-operation was charged with the task of assessing neutron cross-section evaluations for fission products. The undertaking of the task group was considerable: the review and assessment of neutron-induced cross-sections in all major evaluated nuclear data libraries. As a result, the subgroup provided recommendations for the best evaluations for 218 fission products, as set out in this report.

## Fuels and Materials for Transmutation

### A Status Report

*ISBN 92-64-01066-1* *Free: paper or web.*

The safe and efficient management of spent fuel from the operation of commercial nuclear power plants is an important issue. Worldwide, more than 250 000 tons of spent fuel from reactors currently operating will require disposal. These numbers account for only high-level radioactive waste generated by present-day power reactors. Nearly all issues related to risks to future generations arising from the long-term disposal of such spent nuclear fuel is attributable to only about 1% of its content. This 1% is made up primarily of plutonium, neptunium, americium and curium (called transuranic elements) and the long-lived isotopes of iodine and technetium. When transuranics are removed from discharged fuel destined for disposal, the toxic nature of the spent fuel drops below that of natural uranium ore (that which was originally mined for the nuclear fuel) within a period of several hundred to a thousand years. This significantly reduces the burden on geological repositories and the problem of addressing the remaining long-term residues can thus be done in controlled environments having timescales of centuries rather than millennia stretching beyond 10 000 years. Transmutation is one of the means being explored to address the disposal of transuranic elements. To achieve this, advanced reactor systems, appropriate fuels, separation techniques and associated fuel cycle strategies are required. This report describes the current status of fuel and material technologies for transmutation and suggests technical R&D issues that need to be resolved. It will be of particular interest to nuclear fuel and material scientists involved in the field of partitioning and transmutation (P&T), and in advanced fuel cycles in general.

## Pellet-clad Interaction in Water Reactor Fuels

### Seminar Proceedings, Aix-en-Provence France, 9-11 March 2004

*ISBN 92-64-01157-9* *Price: € 110, US$ 138, £ 74, ¥ 14 700.*

This report communicates the results of an international seminar which reviewed recent progress in the field of pellet-clad interaction in light water reactor fuels. It also draws a comprehensive picture of current understanding of relevant phenomena and their impact on the nuclear fuel rod, under the widest possible conditions. State-of-the-art knowledge is presented for both uranium-oxide and mixed-oxide fuels.

## Utilisation and Reliability of High Power Proton Accelerators

Workshop Proceedings, Daejeon, Republic of Korea, 16-19 May 2004

*ISBN 92-64-01380-6     Price: € 120, US$ 150, £ 82, ¥ 16 400.*

Accelerator-driven systems (ADS) are being considered for their potential use in the transmutation of radioactive waste. The performance of such hybrid nuclear systems depends to a large extent on the specification and reliability of high power accelerators, as well as the integration of the accelerator with spallation targets and sub-critical systems. At present, much R&D work is still required in order to demonstrate the desired capability of the system as a whole. Accelerator scientists and reactor physicists from around the world gathered at an NEA workshop to discuss issues of common interest and to present the most recent achievements in their research. Discussions focused on accelerator reliability; target, window and coolant technology; sub-critical system design and ADS simulations; safety and control of ADS; and ADS experiments and test facilities. These proceedings contain the technical papers presented at the workshop as well as summaries of the working group discussions held. They will be of particular interest to scientists working on ADS development as well as on radioactive waste management issues in general.

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