NEA News

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

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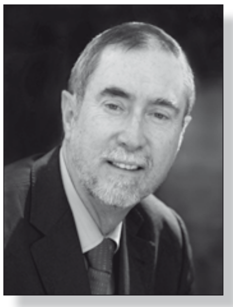

Nuclear energy: half a century of experience

Nuclear energy currently benefits from about 13 000 reactor-years of experience worldwide. This considerably strengthens its ability to ensure very high standards of nuclear safety and radiological protection of workers, the public and the environment. Such experience can also contribute to increased public confidence in nuclear power, provided that the public is well-informed of the various aspects of this energy source as discussed in the article on page 4.

This increasing body of experience is, of course, the result of increasing numbers and years of operation of nuclear power plants. With this comes the need to look more closely at questions of ageing management. The NEA has several studies and projects under way in this area, which are described on pages 16-19. Such studies can also provide useful feedback for the design of new nuclear power plants, and is beginning to be used in many member countries. Ageing management studies and associated analyses are also important when deciding on the possible extension of the lifetime of nuclear power plants, usually by an additional 10 or 20 years depending on the regulatory framework in place, as the prerequisite safety criteria must be defined and met.

A number of nuclear power plants are nevertheless reaching the moment when they need to be decommissioned. The article on page 13 specifically addresses the lessons learnt during decommissioning that can be applied to new reactors. Indeed, this feedback from decommissioning experience can provide useful insight into improvements that can be made at the design stage, with potential economic, radiological protection and waste management benefits.

Overall, the trend towards a revival of nuclear power continues, with many countries showing new or increased interest in nuclear power based on its security of supply and near absence of CO_2 emissions on a full life cycle basis. Financing the necessary investment to build new nuclear power plants will be challenging, however, in the current economic context. Guaranteed loans and other selected measures will enable governments to support cost-effective investments in the nuclear sector without jeopardising market competition.

Luis E. Echávarri
NEA Director-General

Nuclear power and the public

by P. Kovacs and S. Gordelier*

Issues such as climate change, energy security and the longer-term availability of fossil fuels are causing many governments to reconsider their national energy policies. Promotion of renewable energy sources is often a first policy response but, increasingly, it is being recognised that renewable sources may only provide a partial solution, especially in countries where heavy industry or large cities make intense demands on electricity supply. Governments are coming to recognise nuclear power as an attractive option because of its near absence of carbon dioxide emissions and the widespread availability of uranium which serves as fuel. Furthermore, the major uranium producers – Canada and Australia – are noted for their long-term stability and good governance. The difficulty, of course, is that concerns over the safety and security of nuclear power often make it unpopular among the public. Hence, whether governments propose to introduce nuclear power for the first time, to simply replace existing ageing plant or to expand generating capacity, public acceptability questions must be faced.

The apparent intractability of this issue has given rise to innumerable studies of public attitudes to nuclear power. The NEA has recently completed a review of this information – what might be called "a poll of polls". Particularly useful sources of information are surveys conducted for the European Commission (the Eurobarometer series) and the International Atomic Energy Agency (IAEA) between 2005 and 2007. Together, these provide in-depth information that helps to explain country-to-country differences and people's underlying reasons for supporting or opposing nuclear-generated electricity.

Familiarity breeds content?

The results of the Eurobarometer and IAEA polls show that support for nuclear power varies widely between countries. In the countries of the European Union (25 when the poll was conducted), responses to the question "Are you in favour or opposed to the use of nuclear power in your country?" show that those clearly in favour of nuclear power range between 5% (Austria) and 41% (Sweden), with an overall average of 20%. In the IAEA study, polls were conducted in 18 countries. Here, support for the expansion of nuclear power in each country ranges between 13% (Morocco) and 52% (South Korea), with an overall average of 28%. Closer examination of these results clearly shows that, in both polls, support for nuclear power is significantly stronger in countries that already have nuclear power plants. This is illustrated in Figure 1, which shows that people in EU countries that have nuclear power plants are twice as likely to be supportive of this option as people in countries that do not. A similar effect can be seen in the 18 countries in the IAEA survey and indeed, throughout the Eurobarometer surveys in responses to questions such as "Is it possible to operate a nuclear power plant in a safe manner?" and "Do you agree that the disposal of radioactive waste can be done safely?"

One could suppose that people living in countries with nuclear power plants are more supportive of this form of energy because they are more familiar with it, better informed about it and more aware of its benefits. The hypothesis that better and increased communication leads to an increase in support is backed up by a Eurobarometer poll that questioned Europeans about the degree to which they felt themselves to be informed about nuclear safety, and then looked at the impact of this on their views. As

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Figure 1: Percentage of people clearly supporting the use of nuclear power in each of the (then) 25 EU countries, after dividing them into countries with and without nuclear power plants

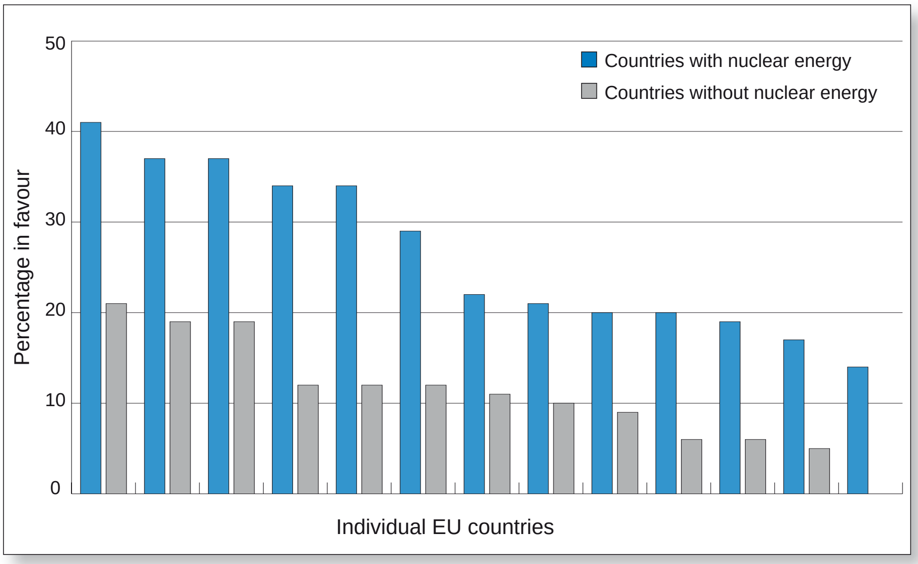
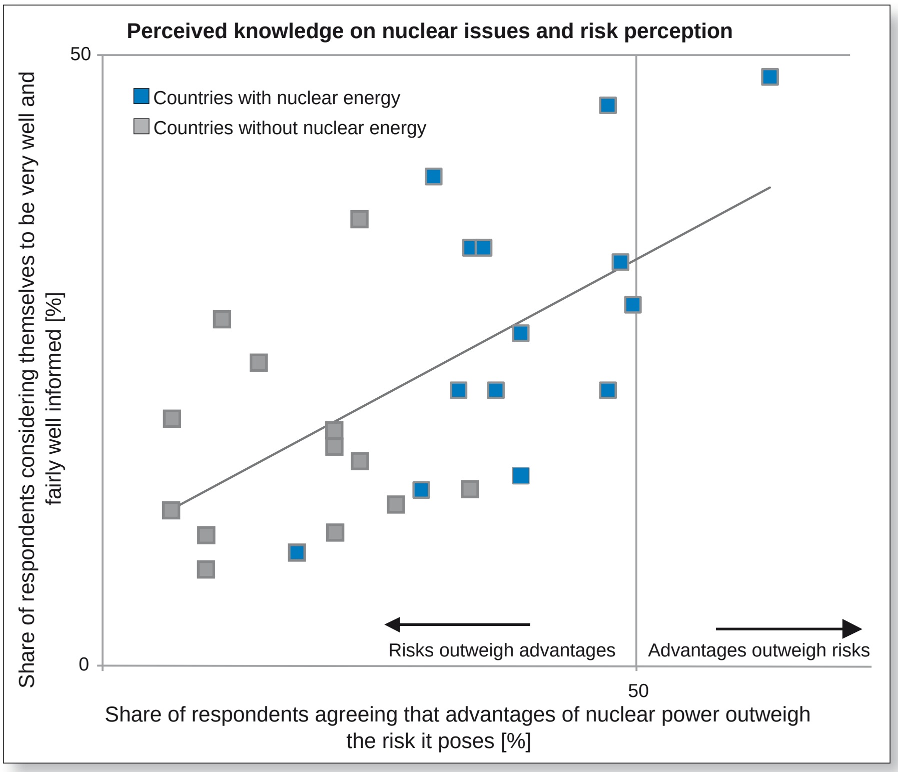


Figure 2: Correlation between the perceived level of knowledge about nuclear power and risk perception. Each spot presents average data for a different European country.



shown in Figure 2, those who feel informed about nuclear safety tend to perceive the risks as lower than those who feel uninformed. A similar link can be demonstrated between lower perceptions of risk and those having personal experience of nuclear power, even when the personal experience amounts to no more than living less than 50 km from a nuclear plant or knowing someone who works in the industry. Again, people in countries without nuclear power plants feel less informed and more likely to say that the risks outweigh the advantages.

More evidence of the effect of knowledge and information on public acceptability of nuclear power comes from polls in which an opinion is sought before and after explaining some key fact. For instance, when it was explained that nuclear power could help to protect the world's climate from global warming, the number of people supporting an expansion of nuclear power increased by an additional 10%, and more than a third of those who originally said that no more nuclear plants should be built subsequently changed their minds. Another, similar poll showed that knowledge about improvements in energy security also increased the proportion of people who were willing to accept nuclear power. Nevertheless, those who definitely favour nuclear power remain in a minority and, comparing the Eurobarometer and the geographically wider IAEA polls, it seems that Europeans are more sceptical than non-Europeans.

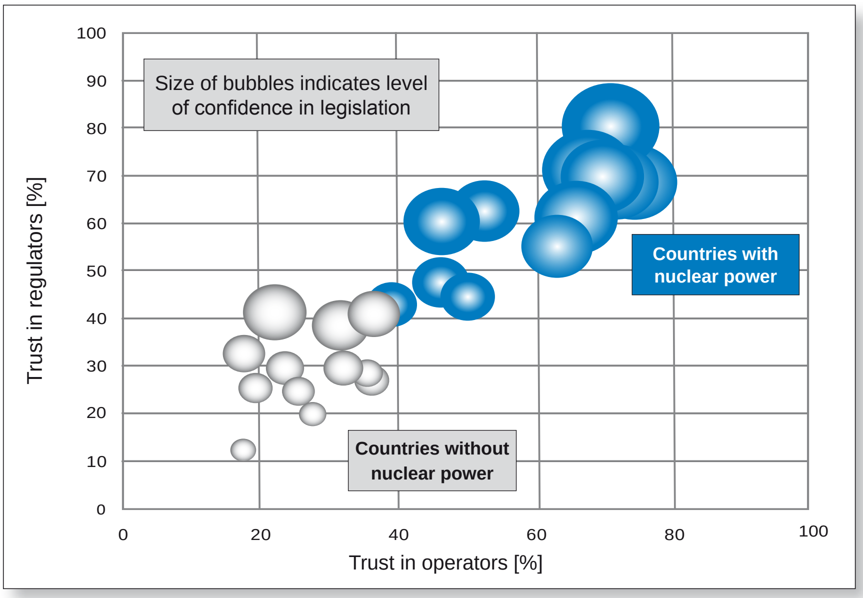
If one places EU respondents into pro-nuclear, anti-nuclear and middle-ground categories, in those countries that already have nuclear power plants, the middle ground is the largest group whereas in countries without nuclear power, those who are anti-nuclear constitute the largest group. This suggests a need for different communication strategies depending on the circumstances of the individual country. Demographically, support for nuclear power is strongest amongst males, those who are educated to a higher level, those with right of centre political views and the older members of society.

Where's the key?

When searching for the reasons motivating public attitudes to nuclear power, the first thing to be acknowledged is that, on a day-to-day basis, most people are much more concerned about issues such as unemployment, crime and healthcare than they are about energy issues, let alone nuclear energy. Even when people are asked "When you think about energy issues, what is the first thing that comes into your mind?", the most frequent response (33%) is "price". This suggests that most people have not given much in-depth attention to the question of energy policy, so that, more often than not, they will respond from a position that is not very well-informed. This may be why so many people are quick to change their minds when presented with evidence to the contrary. Similarly, it is clear that many people may have unrealistic expectations with respect to renewable sources. A Eurobarometer question on future energy sources asked "What do you expect to be the top three energy sources in 30 years?" The most popular choice was solar power (49%), which even came top of the list in a number of northern European countries, a response that certainly overestimates its potential.

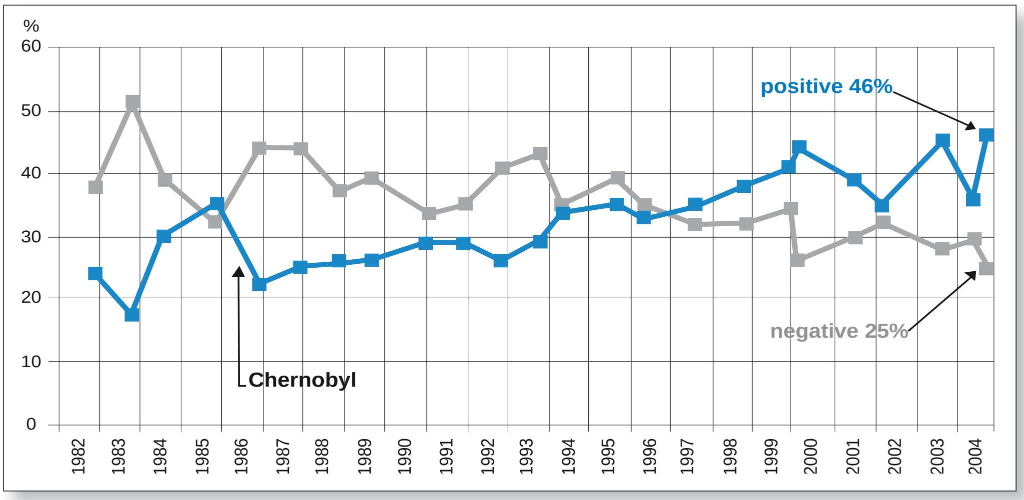
When people were asked to name the biggest risks associated with nuclear power from a list presented to them, terrorism was the most often cited risk (74%). Interestingly, in this case there was little difference in the response between countries that have and do not have nuclear power plants. The next two risks named were radioactive waste disposal (39%) and the misuse of nuclear materials (38%). For these issues, concerns are less pronounced in countries that already have nuclear power plants. More than a third of people who oppose nuclear power say that they would change their view if the issue of radioactive waste disposal could be resolved.

Figure 3: Confidence in European nuclear regulators, operators and legislation



Each bubble represents a different EU country. Confidence in regulators, operators and legislation is strongly correlated. Levels of confidence are higher in countries with nuclear power than in those without.

Figure 4: Attitudes in Finland towards the use of nuclear power since 1982



Source: Suomen Gallop Oy/TNS Gallop Oy/Finnish Energy Industries Federation.

Much of this points to a clear correlation between level of knowledge and support for nuclear power. At the same time, three-quarters of Europeans consider themselves either "completely uninformed" or "not very well-informed". The inescapable conclusion is that more and better public information campaigns are needed in those countries where policy makers want to include nuclear power in the energy mix. But then another difficulty arises: while the media – television, radio and newspapers – are the prime source of information for most people, they are also amongst the least trusted sources. Governments are even more distrusted. According to a Eurobarometer poll, the three most trusted sources are scientists (71%), NGOs (64%) and national nuclear safety authorities (51%).

The public's reluctance to believe information provided by the government suggests that, while it is necessary, supply alone is not sufficient. Measures to raise public confidence in institutions are also needed. In this context, a particularly interesting finding is that levels of public trust in nuclear legislation, nuclear regulators and nuclear power plant operators are strongly correlated (see Figure 3). It is as though, with the mind focused on more immediate issues (unemployment, crime and so on) the public does not look for distinctions between the different actors in the nuclear business, but rather tends to see all parts of the industry in a similar light. Again, higher levels of trust exist in countries that already have nuclear power plants.

A slow, upward trend

Supplementing the information from the Eurobarometer and IAEA polls are the results of regular annual surveys in seven countries: Finland, France, Hungary, Japan, Sweden, the United Kingdom and the United States. These provide details of year-to-year changes and, in the case of Finland (see Figure 4), stretch all the way back to 1982. The Finnish survey shows a sharp drop in support following the Chernobyl catastrophe. A similar fall was seen in Japan after the 1999 accident at the Tokai-Mura reprocessing plant. Since Chernobyl, public opinion in Finland has gradually shifted towards a more favourable view of nuclear power. Similar increases in support are seen in four of the other five countries for which there are time series data. The exception occurs in France where support for nuclear power has stayed relatively constant at around 50% since the surveys began in 1994.

These polls suggest a state of affairs in which, in the absence of dramatic events, public opinion changes only slowly with time. The gradual increase in support that has been seen over the past 20 years may be due to the heightened media profile of energy issues generally and, in all probability, increased familiarity with nuclear power resulting from government and industry information campaigns. Trust-building measures may also have helped; these include improvements in openness and transparency and more active involvement of stakeholders in decision making. The nuclear industry has made great efforts in this direction in recent years. The NEA Forum for Stakeholder Confidence and certain national radioactive waste disposal programmes, such as those in Belgium, Canada and the United Kingdom, place stakeholder interactions at their core. In a world that no longer has any easy energy choices, public acceptance of nuclear power has never been more crucial. ■

Science and values in radiological protection

by T. Lazo*

The NEA Committee on Radiation Protection and Public Health (CRPPH) has been investigating the involvement of stakeholders in decision-aiding and decision-making processes for over a decade. A key conclusion that has resulted from this work is that while the vast majority of radiological protection decisions are informed by science, most decisions concerning public health and safety, or environmental protection, are taken based on broader value-judgement grounds. A relevant corollary to this conclusion is that, in general, the most sustainable decisions tend to be those that clearly reflect and articulate the social values on which they are based.

While these conclusions may seem to be relatively straightforward, applying them to real situations can be anything but. The CRPPH has therefore continued its study of decision making, focusing on case studies of the relationships between scientists and their scientific studies, which can often be uncertain and incomplete, and regulators and their regulatory needs. The objective of this work has been to better understand how, in the face of various levels of scientific uncertainty, value judgements are made and expressed in taking regulatory decisions.

The first step as part of this work was the organisation of the 1st Science and Values in Radiological Protection Workshop, held in January 2008 in Helsinki and sponsored by the Finnish regulatory authority (STUK). The main results of this workshop will be presented here, and have inspired the preparation of the 2nd Science and Values in Radiological Protection Workshop, which will be held from 30 November to 2 December 2009, near Paris, France.

Objectives and approach

There is a constant need for radiological protection policy makers, practitioners and other stakeholders to better understand the evolving interactions between science and values in the development of radiological protection policy and its practical application. Existing radiological protection principles may be challenged by observations of novel or emerging scientific phenomena such as bystander effects, genomic instability, adaptive response and others. Based on this new evidence, attempts are often made to suggest a revision of existing principles or to propose a new paradigm in radiological protection. At the same time, there is also a need for the radiological protection scientists studying these emerging phenomena to better understand the broad processes of radiological protection decision making and to better interact with these processes in terms of furnishing input coming from their research.

In order to explore decision making, and the interactions between scientists and regulators, the objective of the workshop was to initiate a process of reflection and dialogue among the research community, policy makers and other stakeholders that would, in the longer term:

- improve understanding in both the research and policy communities;
- contribute to the development of a more shared view of emerging scientific and societal challenges to radiological protection;
- identify research that will better inform judgements on emerging issues;
- identify elements of a framework that is better suited for the integration of new scientific and

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technological developments and socio-political considerations in radiological protection; and

- identify the most appropriate next steps in this process.

To achieve the above objectives, selected examples of emerging radiological protection issues were addressed in the workshop. Some of the key scientific issues identified in the NEA report on *Scientific Issues and Emerging Challenges for Radiological Protection* (OECD/NEA, 2007) were used as examples in the workshop, namely:

- non-targeted effects;
- individual sensitivity; and
- cardiovascular diseases.

Moderated discussions adopted a "what if" approach, assuming that particular scientific conclusions would be reached by research (e.g. that individual sensitivity can be easily measured and that individual risks can be considerably higher for sensitive individuals). Regulators and researchers then discussed the likelihood of such "what if" situations, and their possible repercussions for RP regulation and practice.

Non-targeted effects

Non-targeted effects refer to those effects that occur in cells not directly hit by ionising radiation. In particular, what are called bystander effects are effects that occur in cells that were not traversed by radiation and are induced by signals from irradiated cells. Another significant not-targeted effect occurs in the genetic offspring of the irradiated cell, where an increased rate of genomic alterations is seen in the progeny of irradiated cells.

Currently there is much that is unknown with regard to these two aspects of non-targeted effects. For example, in the area of bystander effects, what are the chemical messengers that result in damage being manifest in non-irradiated cells? Why does damage only occur in some cells in the vicinity of the irradiated cell? In the area of genomic instability, why does this instability occur irregularly in the family of progeny cells? More generally, it is not known whether these effects are linked to the later appearance of diseases, such as cancer, leukaemia, or cardiovascular diseases, and thus it is not known how these effects may affect the shape of the dose/response curve or the overall model of radiation-induced damage.

Why are non-targeted effects a relevant topic?

The precise nature of radiation-induced damage and the mechanisms that lead to detrimental effects (diseases) are not fully understood. However, it is assumed, for radiological protection purposes, that detriment is proportional to dose. If, however, effects in cells beyond those that are directly hit by ionising radiation influence the genesis of radiation-induced diseases, this would suggest that detriment is not as directly proportional to dose as we currently suspect. If so, the dosimetric criteria on which we currently base protection decisions would need to be revised.

What do we know now about non-targeted effects?

There is a substantial and growing body of knowledge in the area of non-targeted effects, and much research continues in this area. Bystander effects have been induced in unirradiated cells by ionising radiation, as shown in *in vivo* experiments in a human skin cell model, in mouse experiments, and in experiments with blood samples from irradiated humans. Bystander effects are thought to be mediated by cell-to-cell gap junction communication, and they are seen at low doses (on the order of a few mGy). Genomic instability, another type of non-targeted effect, is also known to occur as a result of irradiation. Here, progeny cells which have not been irradiated, and that may be several generations beyond the originally irradiated cell, manifest an instability in their genomic makeup.

What are the scientific issues?

There are many scientific issues that still remain unknown with respect to non-targeted effects, and considerable research is under way in this area, including studies of the nature of the signal-generating bystander effects, and the interaction of that signal with the bystander cell. Other more general questions are also being studied. For example, bystander effects seem to be dose-related only up to a certain low dose, and is primarily a low-dose phenomenon, with higher doses not resulting in further effects. In this context, it is also not fully understood whether targeted and non-targeted cells respond differently.

What are the regulatory issues?

In addition to these scientific questions, the issue of non-targeted effects also raises a series of significant regulatory questions. Broadly, at our current state of knowledge it is not clear whether non-targeted effects amplify the detrimental effects of radiation, and if so, how we would build non-targeted effects into radiation risk estimates.

What approach(es) should be followed to address the scientific issues raised above?

In order to better understand the nature of non-targeted effects, mechanistic studies are essential, focusing on such things as DNA repair at low doses and low dose rates, at differences between the effects of high and low linear energy transfer (LET) radiation, and using new technologies, for example focusing on the significance of foci formation. Genetic susceptibility should be studied, using appropriate model systems, focusing on genetic and epigenetic components, and studying individual differences.

Likely evolution

Better understanding of non-targeted effects would very likely not affect the overall level of risk, but rather would better explain from where the risk originates. Thus, it would not be necessary, based on our current, incomplete understanding, to change the current approach.

Individual sensitivity

Individual sensitivity refers to the tendency of some individuals to be more or less sensitive than other individuals to radiation-induced damage. Such hypersensitivity or hyposensitivity can result from genetic differences, but can also be affected by living conditions (i.e. environmental exposure to other toxic substances) or lifestyle choices (i.e. smoking). The significance of this to the management of radiological protection is that the current system of protection is based on a broad, averaged approach that applies equally to all exposed or potentially exposed individuals. As such, decisions regarding justification, optimisation or limitation will not inherently account for variability in sensitivity, and thus may pose greater risks to some individuals than to others.

Currently, much remains scientifically unknown in this area, for example, the size of the potentially hypersensitive population and the magnitude of their hypersensitivity, the range and types of exposures likely to trigger such hypersensitive reactions, the mechanisms that produce hypersensitivity that may be linked to other environmental factors, etc. However, the fact that such populations may exist can pose ethical and regulatory issues that should be considered so as to avoid the need for hasty and insufficiently considered reactions by regulatory authorities should scientific discoveries arise confirming relevant hypotheses.

Why is individual sensitivity a relevant topic?

It is known that, at the high doses to which radiation therapy patients are subject, about 5% of cancer therapy patients are hypersensitive to radiation and express skin lesions much more frequently than other cancer therapy patients. This sensitivity is thought to be driven due to genetics, but it is not clear whether increased sensitivity to high exposures would also result in increased stochastic effect risks in humans, although this has been seen in animal studies.

In addition, it has been known for some time that, on average, women are twice as sensitive to radiation-induced stochastic effects (mostly breast cancer) than men, and that, again on average, young children (about five years and under) are roughly five times as sensitive to radiation-induced stochastic effects as adults. While it is generally true that risk differences of less than an order of magnitude are well within the statistical uncertainty of our current level of knowledge, stakeholders may not feel that differences of a factor of two or five should be dismissed as a statistical noise.

What do we know now about individual sensitivity?

Individual sensitivity is known to be expressed at high doses, that is, levels experienced by patients undergoing radiation therapy, and may be expressed at low doses, for example, exposure levels experienced by occupationally exposed workers and by the public in general. With respect to radiation therapy patients, as previously stated 5% are hypersensitive to radiation, and of these, 5% (or 0.25% of all therapy patients) are very hypersensitive. Importantly, it is also suspected that there are some people who are hyposensitive to radiation, but the size of this group is not known.

What are the scientific issues?

High-dose considerations are particularly relevant because they are known to exist in radiation therapy patients. In particular, the link with specific genetic characteristics is being used to develop predictive tests that would indicate whether or not an individual would be likely to be hypersensitive to radiation. However, for such tests to be truly useful in helping to define an individual's treatment strategy, it is important to better understand the mechanisms and consequences of effects caused by hypersensitivity and their applicability, that is, at what range of exposures they might occur, what effect age at exposure may have, etc. Of course, any predictive tests would need to be suitably validated for accuracy and precision.

What are the regulatory issues?

In addition to these scientific questions, the issue of individual sensitivity also raises a series of significant regulatory questions. For example, since hypersensitive individuals are included in the exposed populations that have been used as the basis for the estimation of radiological risk, in particular the populations of Hiroshima and Nagasaki, does this sufficiently take into account the risks of hypersensitive individuals? In fact, is most of our current risk estimate actually due to risks in these individuals? If so, would it be appropriate to re-evaluate our current approach to radiological protection, either identifying a new dose limit to best protect hypersensitive individuals and another for "normal" individuals, or keeping a single dose limit but setting it as a function of risks to hypersensitive individuals. In addition, if hypersensitivity is an issue (with individuals being at two or more times the "normal" risk) there would be a need to explore several other regulatory aspects, including protection of emergency response workers, and, depending on the relevant level of exposure perhaps protection of the public (sensitive groups) in emergency situations (implications for the current approach to planning emergency response optimisation for women, pregnant women and children).

What approach(es) should be followed to address the scientific issues raised above?

Given these types of scientific questions, credible strategies should include single-cell models and animal models, although the relevance of these to organs and humans need to be evaluated. To move forward, there is a need to develop research priorities, requiring an active dialogue between researchers and the regulatory and broader radiological protection community. A key aspect in the prioritisation of research will be to clearly agree on how to judge the likelihood of these studies to deliver answers, and to consider whether risk-modifying factors (age, diet, lifestyle, etc.) influence sensitivity.

Likely evolution

An important challenge posed by our current level of knowledge is the need to assess what changes would need to be made in our current radiological protection approach as knowledge evolves. Adopting a "what if" approach, several changes can be foreseen once the sensitive population has been more sufficiently characterised (i.e. what fraction of the population, how hypersensitive they are, how do age and sex influence sensitivity, etc.). Based on this level of understanding, it is likely that radiological protection changes would be considered for both high- and low-dose situations.

However, based on our current level of knowledge, and in particular on our understanding of the probable levels of increased risk should large populations of hypersensitive individuals exist, there seems to be no need to radically modify the current approach to radiological protection. No specific changes are recommended for occupational protection, protection of the general public, or for public screening programmes (i.e. medical screening or medico-legal screening).

A key aspect of this issue is the reflection of living with scientific uncertainty, and being prepared to react in an appropriate fashion should new evidence arise. Hence, and again based on current knowledge, it is suggested that in emergency exposure situations, medical diagnosis situations and medical therapy situations, some consideration should be given to refocusing protective actions taking individual sensitivity into account.

Cardiovascular diseases

It has been generally accepted that high dose (several Gy) radiation exposure to the heart or other parts of the circulatory system result in long-term increases in cardiovascular disease risks. Over the past 10-15 years, evidence has been emerging from the long-term follow-up of atomic bomb survivors and other populations that relatively low dose acute exposures (< 2 Gy) are also associated with increased cardiovascular disease risks.[1] Although the estimated relative risks are smaller than for cancer, it is clear that radiation-associated cardiovascular disease deaths will account for a substantial fraction of the total radiation impact on mortality in the atomic bomb survivors. However, those epidemiological data do not, and probably cannot, provide definitive evidence of increased cardiovascular disease risks following low dose (e.g. 0.005 to 0.5 Gy) exposures. Despite this uncertainty, these findings have increased interest in efforts to identify mechanisms for long-term radiation effects on the circulatory system and prompted the re-examination of cardiovascular disease risks in other populations.

Why are cardiovascular diseases a relevant topic?

Cardiovascular diseases are currently not specifically addressed by the radiological protection system. The ICRP recognises the existence of this problem, but notes that experimentally observable dose-associated effect is at high doses, around 1 Gy.[2] There are still uncertainties regarding the shape of the dose response at low doses and whether these effects have a threshold at around 0.5 Gy or not at all. In general, the ICRP accepts that available data do not allow for their inclusion in the estimation of detriment following low radiation doses less than 100 mSv. This also agrees with the conclusion of the 2008 UNSCEAR report which found little evidence of any excess of risk below 1 Gy.[3]

The 2008 UNSCEAR report includes an annex on this topic and it seems inevitable that the ICRP and other groups involved in the formulation of regulatory guidelines will have to address the question of how to incorporate potential cardiovascular disease risks into the evolving system of radiological protection.

Regulatory issues and likely evolution

If potential changes in radiological protection principles are made based on available Japanese risk estimates and the linear no-threshold (LNT) hypothesis considering risk for cardiovascular diseases, there will be a need for significant revision. Current dose limits would need to be lowered by 30-50%, with strong emphasis on optimisation. In such a case, the application of the precautionary principle should include not only the change in detriment but also the cost and other consequences associated with this change. If this is the case, the current radiological system will be significantly challenged. However, workshop participants also recognised that any potential change should be made in the light of evolving science and serious value judgements, and thus further research and dialogue is needed.

Moving forward

The 1st Science and Values in Radiological Protection Workshop was the first in the intended series of CRPPH workshops addressing emerging scientific issues and questions on the potential need to revise and/or to amend existing radiation principles and radiological protection criteria. It sought to initiate a discussion on the universality of the current fundamental radiological protection approaches and how it may be challenged by novel scientific issues. It aimed to provide insights into how agreement is reached regarding a "tipping point", that is, when the scientific and social aspects considered by policy makers and regulators hold sufficient weight to "tip" the scales towards a new regulatory approach or paradigm. It was felt that the discussions at the workshop, briefly summarised above, were a good beginning to better understanding various aspects of this important scientific and social question.

The CRPPH agreed that the second science and values workshop should re-emphasize that radiological protection is a combination of science and value judgements, and should focus on radiological protection issues that are currently being faced and continue to pose challenges. As such, the second workshop has been designed to address a series of current radiological protection issues from the standpoint not of "What if?", but rather, "What now?". This workshop will examine the social and scientific challenges posed by radon, by growing medical exposures, and by emerging radiological risks of cardiovascular diseases.

In these three areas chosen for the workshop, current approaches to radiological protection have not fully yielded the desired results (i.e. radon and medical exposures), or there is a perception that there is insufficient scientific evidence to warrant change in the current approach (i.e. cardiovascular diseases). Thus, while the objective of this workshop is not to develop detailed recommendations as to new approaches, it is expected that:

- Stakeholders in each area will present and exchange experience related to their viewpoints and relevant values, increasing their levels of mutual understanding to facilitate development of common approaches.
- Participants will discuss social and scientific rationale and justification of the need to adopt new approaches to radiological protection in each of these areas (tipping point).
- Practical approaches to improving radiological protection in each area will be discussed based on national experience.
- Participants will identify possible needs for further research and/or analysis in order to better understand the challenges and how they may be accommodated.
- Process and framework elements that could enhance radiological protection in these three areas by better integration of social and scientific aspects will be identified.

It is hoped that this workshop will result in a better understanding of how these judgemental decisions can be made in an increasingly transparent fashion, making clear their bases and their assumptions. It is also hoped that the discussion of these topics will provide participants with different national and institutional views of how to best address the challenges posed in these areas. A report summarising the results of this workshop will be published by the NEA in 2010. ■

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Applying decommissioning experience to the design and operation of new nuclear power plants

by P. O'Sullivan, C. Pescatore and I. Tripputi*

The NEA Working Party on Decommissioning and Dismantling (WPDD) has recently undertaken a study on current approaches to applying experience from decommissioning to the design and licensing of third generation reactor systems. This study was motivated by the increased interest in several NEA countries in embarking on new nuclear power plant construction programmes relying on these reactor systems.

A report is being prepared based on information provided by regulatory authorities, electricity producers and reactor design organisations concerned with the development and implementation of new reactor systems. Initial information was provided in response to a survey whose results were subsequently discussed at a WPDD topical session in the presence of the survey respondents and of representatives of the Western European Regulators' Association (WENRA), FORATOM and the IAEA's Waste Technology Section.

The study's final report is expected to be published during 2009. Main findings are outlined hereafter.

Overview

Experience from decommissioning projects suggests that the decommissioning of nuclear power plants could be made easier if this aspect received greater consideration at the design stage and during operation of the plants. Better forward planning for decommissioning results in lower worker doses and reduced costs. When appropriate design measures are not taken at an early stage, their introduction later in the project becomes increasingly difficult. Hence, their early consideration may lead to smoother and more effective decommissioning. This has prompted national authorities and electricity producers to demand that decommissioning needs be addressed from the design stage and that preliminary decommissioning plans be provided as an input to the licensing process.

Reflections on good practice

Preliminary decommissioning plans

In recent years, it has become commonplace that decommissioning plans are developed at an early stage, subsequently revised as necessary throughout the lifetime of a nuclear installation and resubmitted periodically for approval by the competent national authorities. Together with conceptual strategies for dismantling the installation, these plans typically

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discuss the management of waste arising from decommissioning operations, the intended end state of the site and related environmental issues, and are used as a basis for showing that adequate financial provision for decommissioning is being made. This trend is, in turn, leading to greater emphasis being given to associated issues such as the choice of materials for construction, provisions for ease of maintenance and dismantling, providing means for limiting contamination and the definition of national clearance levels.

Decommissioning plans should address, at an appropriate level, the necessary design provisions in order to minimise the creation of radioactive waste, by limiting and controlling activation and contamination, and facilitating decontamination; to simplify dismantling and equipment handling; to enable onsite management of materials and waste; and to facilitate site release.

Elaborating the dismantling sequence at the design stage may be very beneficial in identifying design improvements beneficial to decommissioning, and hence in reducing uncertainties on dismantling costs. A clear strategy for minimisation of radioactive materials will also be very helpful in reducing waste management costs.

Overlap between operating and decommissioning requirements

An important priority for utilities is that the design provide for optimal operation and maintenance (O&M) of the facility. Design features that support O&M work will invariably also be beneficial for later decommissioning tasks. Good design practices for both O&M and decommissioning include: providing ample space for the activities being undertaken, minimisation of doses during these activities, minimisation of waste quantities, keeping plant contamination levels low, providing adequate handling capability and making provision for replacement of components. Minimisation of waste arisings is achieved, for example, through careful selection of materials and by incorporating features to limit the spread of potential contamination to clean areas and systems.

In addition to consideration being given to the nuclear island, attention should also be given to the overall balance of the plant, as areas which are difficult to access could later give rise to problems during decommissioning. In general, it is good practice to submit the entire plant to a structured review from the perspective of decommissioning.

Designing for decommissioning

Although many design requirements aimed at improved O&M will also be beneficial for decommissioning, there are nonetheless certain design considerations that need to focus directly on plant decommissioning and dismantling. Design provisions specific to decommissioning include designing structures for long-term stability and including features aimed at minimising infiltration, containing spills and releases, and retarding contaminant transport. Decommissioning experience to date suggests that greater consideration should be given to identifying the key components of particular reactor systems that are directly related to decommissioning and to defining the boundaries of these systems, regardless of the decommissioning strategy.

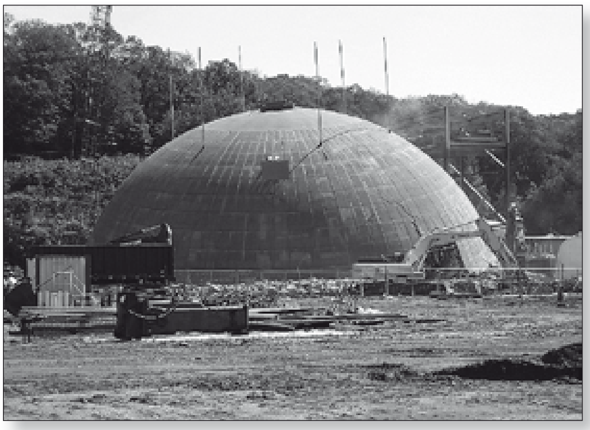
Current good practice is to implement technical provisions that circumvent the use of embedded piping, for example by routing piping in accessible areas such as dedicated pipe tunnels or trenches, or by using double barriers for all pipes traversing concrete walls or floors. Leaks in embedded piping are difficult to locate and may lead to larger amounts of waste and longer outages during plant operation. At the same time, potential radiation doses from unshielded piping need to be addressed in designing the provisions for radiation protection.

Careful optimisation of design provisions for decommissioning with those of "downstream" waste management, including making provision for facilities and space for onsite management of waste, may be expected to yield benefits in terms of reducing radiation exposure of the workforce and decommissioning costs.

Plant record systems and plant configuration management

Early consideration should be given to the needs of plant configuration management, including developing systems for maintaining records of the physical configuration of the plant on an ongoing basis. Experience from recent decommissioning projects suggests that plant records may sometimes be incomplete or inaccurate, and consequently may not reflect the final plant configuration. Plant management systems should be designed to include, in addition to those records that are directly relevant to operation, other records that might be important for decommissioning. For example, information on temporary openings made during construction may facilitate the reuse of these accesses during decommissioning.

The development of 3D models as part of the design process provides a useful management tool throughout plant operation, including for showing how configuration control can be maintained during sequential dismantlement and for visualising the locations of sources of activity to help assess where samples should be taken for radiation monitoring.



Demolition of the containment building
of Connecticut Yankee nuclear power plant.

It is good practice to retain records of the original composition of steel and concrete materials used in the plant (including technical specifications), as knowledge of any impurities may be important for future decommissioning and can reduce the extent of material characterisation that is ultimately needed. Materials used for the construction of neutron shields are of special importance. In particular, it is beneficial at the design stage to specify the allowable range of cobalt levels in steel, as well as seeking to reduce cobalt levels in absolute terms, as quantities of certain other radionuclides are often estimated from the cobalt levels. Overall, this will facilitate management of radionuclide inventories.

Plant monitoring systems

It is good practice to provide monitoring systems for early detection of leaks and contamination, including leaks from underground piping (environmental monitoring). Providing means for monitoring plant chemistry parameters, with the objective of minimising corrosion of metallic components, is also desirable. Plant operators need to give particular attention to recording this information, as such contamination may otherwise only be identified during demolition of the concrete structure.

Towards greater standardisation of design requirements

The design guidelines established by the electricity producers (as clients) provide an essential link between past experience and the design process. These guidelines need to be developed taking account of discussions with designers about what features can reasonably be delivered.

In Europe, the main electricity producers have developed standardised requirements intended to ensure that all reactor designs for the European market incorporate certain basic design features, including making provision at the design stage for waste minimisation and component removal. The European Utilities' Requirements (EUR) for light water reactors (see www.europeanutilityrequirements.org/) address in particular aspects such as material selection for reduced dose rates, good surface finishing to facilitate decontamination of materials and providing easy accessibility for removal of plant components. It is understood that the Utility Requirements Document (URD) of the Electric Power Research Institute (EPRI) will be updated to provide equivalent requirements in the coming years.

Regulators have also begun developing standardised requirements, for example through the Safety Reference Levels (SRLs) for decommissioning and waste management being developed by WENRA for use in Europe. Central to these requirements is the development of a preliminary decommissioning plan prior to the issuing of a construction licence, and the updating of this plan throughout the lifetime of the nuclear facility. The plan should take account of a safety assessment for decommissioning that is also updated periodically during the life of the facility.

Making decommissioning experience available to reactor designers

The need to incorporate dismantling lessons both at the design stage and during the whole life of a facility could be better fulfilled if dismantling experience were systematically collected, analysed and recorded. It is clear that design organisations are making positive efforts to take greater account of decommissioning needs in the design of new plants. At the same time, with some important exceptions such as the US Nuclear Regulatory Commission, it seems that there have been few systematic attempts to capture the lessons from dismantling experience, and it is not clear that there is a systematic process for integrating these lessons into the design of new plants.

An important consideration here is that, within utility and regulator organisations, the areas of design, operation, and dismantling and decommissioning are often handled by different departments. Sometimes, the responsibility is even assigned to different organisations altogether, requiring special attention to be given to co-ordination of information transfer between the different groups. The NEA study has provided an opportunity for regulators, utilities and design organisations to share their different perspectives and experience on how requirements for decommissioning should be reflected in new plant designs. ■

Ageing management

by A. Blahoianu, K. Gott, A. Huerta, N. Sekimura and A. Yamamoto*

Ageing management is generally defined in a broad sense covering not only ageing management of "hardware" (structures, systems and components), but also management issues such as keeping up with developments in state-of-the-art technology and the latest management practices. The importance assigned to "traditional" ageing management, in terms of issues related to hardware degradation problems, is clearly very high. The other aspects, for example developments in engineering or management, are considered important as well, but are less emphasized.

Plant ageing management is composed of the following necessary elements, which are all linked together:

- understanding and knowledge of ageing-related damage mechanisms, including benchmarking of the consequences of damage mechanisms into macroscopic behaviour of materials and structures under applicable conditions;
- predictive models to extrapolate behaviour of systems, structures or components up to a defined time;
- qualified methods for detection and surveillance of ageing degradation;
- qualified mitigation, repair and replacements measures;
- reliable plant documentation, including optimisation of the ageing management programme based on current understanding and knowledge and periodic self-assessment;
- availability of a technical service and knowledge base.

The subject of plant ageing management has gained increasing attention over the past years, notably as more nuclear power plants across the world are being considered for lifetime extension. In this context, the NEA has conducted numerous technical studies to assess the impact of ageing mechanisms on safe and reliable plant operation. International research activities have also been initiated or are under way to provide the technical basis for decision making.

This article provides an overview of some of the activities and accomplishments of the NEA Committee on the Safety of Nuclear Installations (CSNI) Working Group on the Integrity and Ageing of Components and Structures (IAGE), the OECD/NEA Piping Failure Data Exchange (OPDE) Project and the OECD/NEA Stress Corrosion Cracking and Cable Ageing Project (SCAP).

NEA regular activities on ageing mechanisms

The focus of the IAGE activities has been on improving knowledge and understanding of ageing mechanisms, assessing material properties, operating conditions and environmental effects, potential degradation locations and the consequence of degradations and failures. Activities have also been devoted to the inspection, monitoring and assessment portion of ageing management programmes as well as assessing mitigation, repair and replacement measures.

Due to the expertise required for addressing integrity and ageing issues of different components, the IAGE is supported by three subgroups dealing with the integrity and ageing of metallic

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components, the integrity and ageing of concrete structures and the seismic behaviour of components and structures.

Thermal cycling is a widespread and recurring problem in nuclear power plants worldwide. Several incidents with leakage of primary coolant water inside the containment has challenged the integrity of nuclear power plants, although no release outside the containment has occurred. Thermal cycling is a complex phenomenon that involves thermal-hydraulics, fracture mechanics, materials and plant operation. The IAGE undertook a programme of work on thermal cycling to provide information to NEA member countries on operating experience, regulatory policies, countermeasures in place, and the current status of research and development, as well as to identify areas where research is needed both at the national and international levels.

The programme included:

- A review of operating experience, regulatory frameworks, countermeasures and current research; the results were documented in NEA/CSNI/R(2005)8.
- A benchmark to assess calculation capabilities in NEA member countries for crack initiation and propagation under a cyclic thermal loading, and ultimately to develop screening criteria to identify susceptible components; the results of the benchmark were issued in NEA/CSNI/R(2005)2.
- The organisation of a series of international conferences on fatigue of reactor components, which review progress in the area and provide a forum for discussion and exchange of information between high-level experts; the conferences are held every two years to monitor progress and to focus research on key aspects.

In addition, the IAGE is about to start a new activity intended to assess fatigue data transferability from standard specimens to structures and components, including environmental effects. Objectives are to confirm code practices for analysing fatigue of components, to propose a synthesis of existing fatigue tests performed on components and structures and to select a set of reference tests to verify proposed regulations in different countries.

There have been several instances of primary water stress corrosion cracking in nickel-based alloys and weldments. Recent examples include cracking at safe ends of primary loop piping and in reactor vessel head penetrations. While considerable research has been ongoing for steam generator tubing, there is an incomplete understanding of susceptibility of the thick sections. This is needed for alloys used in the existing components as well as alloys used for the replacements. The NEA has generated considerable information on events related to stress corrosion cracking, including comparisons between operating experience, inspection practices and acceptance criteria applied in different countries [NEA/CSNI/R(2006)8], as well as piping failures through the OPDE Project, and SCC component failures through the SCAP Project, which is consolidating the acquired knowledge and experience into commendable practices.

The effect of radiation on the reactor pressure vessel material resulting in embrittlement has been the subject of various CSNI activities, due to its potential to reduce the safety margins in the event of pressurised thermal shock. Pressurised thermal shock is still a relevant issue for lifetime extension, and its analysis requires a large amount of data as well as consideration of their uncertainties (transients, material properties and flaw distribution). As the deterministic approach is too conservative, probabilistic methodologies are used or under development in many countries.

NEA project on piping failure

Structural integrity of piping systems is important for plant safety and operability. In recognition of this, regulatory authorities of 11 countries decided to collect information on degradation and failure of piping components and systems. The OECD/NEA Piping Failure Data Exchange (OPDE) Project, established in 2002, provides systematic feedback in such areas as reactor regulation and research and development programmes associated with non-destructive examination (NDE) technology, in-service inspection (ISI) programmes, leak-before-break evaluations, risk-informed ISI and probabilistic safety assessment (PSA) applications involving passive component reliability.

The OPDE project addresses typical metallic piping components of the primary coolant system, main process and standby safety systems, as well as support systems (i.e., ASME Code Classes 1, 2 and 3, or equivalent). It also covers non-safety-related (non-Code) piping, which if leaking could lead to common-cause initiating events such as flooding of vital plant areas. The types of degradation or failure include service-induced, inside-diameter pipe wall thinning and non-through-wall cracking as well as pressure boundary breaches such as pinhole leaks, leaks, severance and major structural failures (pipe breaks or ruptures). In other words, the OPDE database covers degradation and failure

Overview of the OPDE database content

Degradation/damage mechanism	Number of database records by failure type		
	Non-through-wall crack/wall thinning	Active leakage	Structural failure
Corrosion (including crevice corrosion, pitting, galvanic corrosion, microbiologically-induced corrosion)	45	272	5
Design, construction and fabrication errors	79	239	9
Erosion-corrosion and flow-accelerated corrosion	190	327	50
Stress corrosion cracking (including ECSCC, IGSCC, PWSCC, TGSCC)	837	273	0
Thermal fatigue (including thermal stratification, cycling and striping)	62	63	3
Vibration fatigue	60	810	48
Other [including erosion-cavitation, fretting, severe overloading/water hammer, strain-induced corrosion cracking (SICC), classification pending]	48	147	44
Total	**1 321**	**2 131**	**159**

of high-energy and moderate-energy piping as well as safety-related and non-safety-related piping.

As of June 2009, the OPDE database included approximately 3 600 records on pipe failure data from 321 nuclear power plants representing 8 300 reactor-years of commercial operation. Roughly half of the records relate to PWRs, 44% to BWRs and 4% to PHWRs. The table above presents an overview of the OPDE database content.

NEA project on stress corrosion cracking and cable ageing

The OECD/NEA SCAP project began in 2006 and is being financed by a Japanese voluntary contribution. The project, to be completed in 2010, will establish a complete database and a knowledge base for stress corrosion cracking (SCC) and cable ageing, and to perform an assessment of the data to identify the basis for commendable practices which would help regulators and operators enhance ageing management.

The SCAP SCC database addresses degradation or failure of passive components attributed to SCC, occurring at nuclear power plants in participating countries. The scope of the database includes ASME Class 1 and Class 2 pressure boundary components, reactor pressure vessel internals and other components with significant operational impact, excluding steam generator tubing. The following mechanisms are considered: inter-granular SCC in austenitic stainless steel and nickel-based material, irradiated-assisted SCC, primary water SCC, external chloride SCC and transgranular SCC.

The SCAP cable database covers safety-related cables (including those supporting emergency core cooling), cables important to safety (cables that are needed to prevent and mitigate design basis events) and cables important to plant operation (cables whose failure could cause a plant trip or reduction in plant power). The scope of the database includes cables with voltage levels up to 15 kV AC and 500 V DC, including instrumentation and control (I&C) cables. The cable database will assist regulatory authorities, plant owners, operators and designers in their decisions on suitable cable choices for mild and harsh environments and in their assessments of existing cable performance.

The SCAP project has established the database performance requirements, data format and coding guidelines and is currently focusing on populating the database and assessing the data collected. The database, together with the knowledge base and the commendable practices to be developed, will provide a tool for assisting member countries in developing suitable ageing management programmes. The final project report will be issued in 2010 and will describe the technical basis for commendable practices in support of regulatory activities in the fields of SCC and cable insulation. A final workshop will be held in May 2010 to present and to discuss the results of the project.

Additional aspects of ageing management

Over the past few decades, the nuclear industry has experienced service degradation of many components, both in the primary and secondary coolant systems. This degradation and the related inspections, together with economic and political factors, have consequently created pressure for more efficient and cost-effective, in-service inspection programmes to ensure that there are adequate safety margins so that anticipated degradation of components does not lead to failures that result in accidents or even unplanned shutdowns with adverse effects on power production reliability. In this context, nuclear regulators and utilities in many countries have developed and implemented risk-informed inspection approaches together with more stringent requirements for demonstrating the performance of the non-destructive testing (NDT) systems that are being used for inspecting safety-related components which are susceptible to different kinds of degradation mechanisms.

The IAGE collected and compiled risk-informed ISI practices and status in NEA member countries through a questionnaire, and the results were documented in NEA/CSNI/R(2005)3. To complete the technical information, a CSNI workshop was held in Stockholm, Sweden. Papers presented at the workshop were issued in the proceedings under reference NEA/CSNI/R(2004)9. Based on the information collected, a Status Report on Developments and Co-operation on Risk-Informed In-Service Inspection and Non-destructive Testing (NDT) Qualification in OECD/NEA Member Countries was issued under reference NEA/CSNI/R(2005)9.

In order to guarantee structural integrity, ageing management is also important for all concrete structures fulfilling a nuclear safety function. Consequently, various national and international programmes have investigated ageing effects and potential failure mechanisms in order to improve understanding of the mechanisms involved.

A programme of workshops run under CSNI auspices has directly addressed the concerns of designers, operators and regulatory bodies with regard to the performance of nuclear facilities' concrete structures. The workshops have allowed the exchange of information and good practice among individual plants, and national and international programmes, and have informed decision making in other international bodies such as the IAEA and the EC. The workshop topics included pre-stress loss [NEA/CSNI/R(97)9], non-destructive examination in concrete [NEA/CSNI/R(97)28], finite element analysis of degraded concrete structures [NEA/CSNI/R(99)1], instrumentation [NEA/CSNI/R(2000)15] and monitoring and repair [NEA/CSNI/R(2002)7].

In 2008, the IAGE sponsored a Workshop on Ageing Management of Thick-walled Concrete Structures, including ISI, Maintenance and Repair, Instrumentation Methods and Safety Assessment in View of Long-term Operation. The objective of this workshop was to present and to discuss state-of-the-art techniques for the integrity assessment of concrete structures, and to recommend areas in which further research was warranted. Special emphasis was given to performance-based in-service inspection based on non-destructive examination methods (such as impact echo, ultrasound and high frequency radar) and instrumentation. Limits of applicability were extensively discussed. Ageing management programmes based on suitable structural monitoring was also addressed in the framework of safety assessments of the installations for long-term operation. Probabilistic methods used for reliability structural assessments were also discussed in terms of consistently managing integrity assessments of civil structures.

Finally, the IAGE seismic sub-group has been involved in many activities aimed at assessing the seismic safety of nuclear power plants. In 2008, the seismic sub-group published a report summarising the conclusions and recommendations of the workshops on engineering characterisation of seismic input, the relation between seismological data and seismic engineering, and on seismic input motions incorporating recent geological studies. The IAGE seismic sub-group also conducted a specialist meeting on seismic hazard assessment and is currently addressing assessments of seismic impact on degraded metal components. In this context, it is discussing the worldwide implications for nuclear facilities of the 16 July 2007 Niigata-ken Chuestu-oki earthquake and its effects on the Kashiwazaki-Kariwa nuclear power station. ■

The Forum on Stakeholder Confidence

by C. Pescatore*

The NEA Forum on Stakeholder Confidence (FSC) meets regularly to share experience about the societal dimension of radioactive waste management. It fosters learning about stakeholder dialogue, reflection about improving decision-making processes, and the search for ways to develop shared societal confidence, consent and approval of management solutions. The FSC brings together operators, regulators, researchers and government decision makers from 16 countries.

Recently, the FSC has explored means of communicating about safety through the use of "analogues" – examples drawn from nature or from man-made constructions – which can help all stakeholders to grasp, and regulators to assess, the technological arrangements proposed for handling radioactive waste. An FSC topical session was held on 4 June 2007 on the use of analogues to help understand and to build confidence in radioactive waste management approaches and safety cases. Case studies were presented from Finland, Spain and Switzerland and from joint international endeavours (EC projects NANET and PAMINA). Timescales relevant to long-term safety of waste disposal in a geological repository (on the order of several centuries, millennia and sometimes more) cannot be attained in experiments. Regulators need a technical demonstration to aid in evaluating the arrangements put forward by the implementer in the formal safety case. Political decision makers and local stakeholders appreciate the opportunity to visualise technological solutions. In both cases, demonstration can add to confidence in the feasibility of such solutions. An example may be given of comparing earthquake damage in a mine with possible damage in a geological repository when affected by a similar event. This situation, which corresponds to a high degree with the modelling and engineering applications expected in a geological repository, serves as a contemporary analogue. As such, it provides very valuable input for the design of underground structures and their supports.

In parallel, the FSC has looked into what can be called the "symbolic dimension" of radioactive waste management. The FSC intends to become better aware of "symbolic" meanings (i.e., meanings that, for different groups, may resonate beyond the obvious) in their actions. Deep-seated values and norms, knowledge and beliefs, group identification, cultural tradition and self-interest are some examples of factors that shape perceptions and interpretations. FSC members want their behaviour, decisions and writing to be highly coherent with the societal values embodied in waste management endeavours. Awareness of additional dimensions of meaning beyond dictionary definitions, and recognition that dialogue is shaped by more than just concrete realities, may help to find ways of creating non-confrontational and constructive relationships between institutional actors and civil society. On 5 June 2008 the FSC held a topical session on this theme. The ensuing report [NEA/RWM/FSC(2008)5/REV2] explains the concepts and includes illustrations of how nuclear installations have changed meaning over the years. Of particular interest is the changing view of waste management facilities that comes about when local partnerships are formed between

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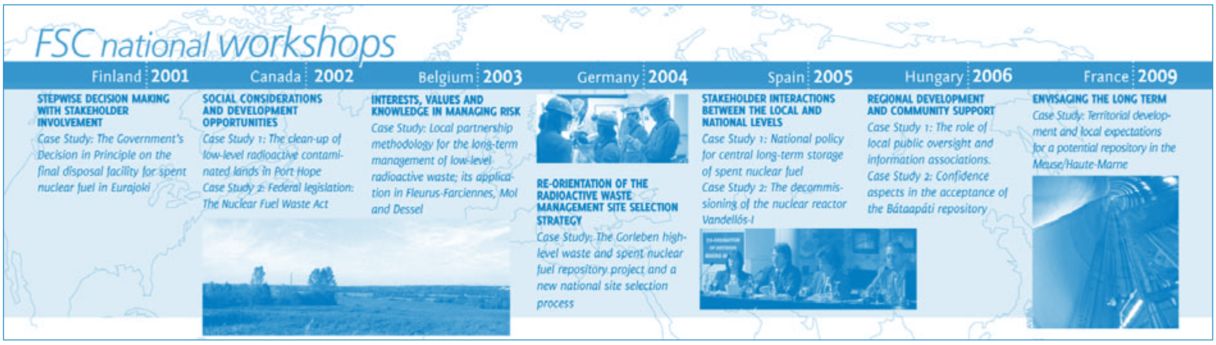


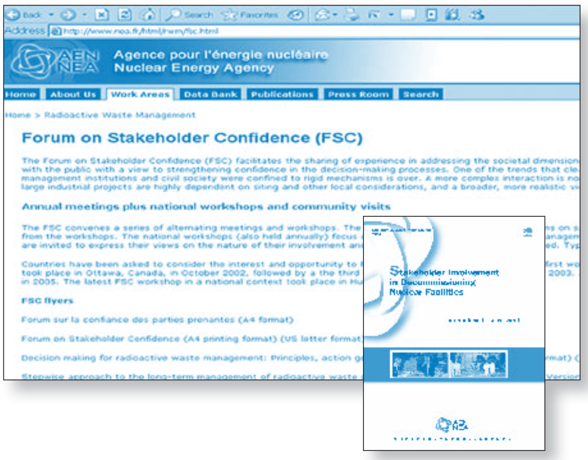
implementers and civil society representatives with the mission to define an integrated, socio-technical design concept.

With its national workshops and community visits, the FSC provides a setting for direct exchange among stakeholders of many backgrounds, in an atmosphere of mutual respect and learning. The seventh FSC workshop was held in early April 2009 in the east of France, in the Meuse/Haute-Marne region. This area currently hosts the Bure underground laboratory (created by French law to pursue research on the geological disposal solution for the management of high-level and long-lived radioactive wastes). In 2006, Parliament approved the principle of constructing a reversible waste repository targeting operation, if authorised, in 2025. The process of selecting the exact location within the area is under way. The FSC workshop entitled "Repository Project and Territories" brought together the potential host communities to exchange views with international delegates on the issues raised by such a project. The workshop was attended by 90 people including six mayors and seven municipal representatives.

One session was dedicated to the review of the historical developments and national framework of the French national programme for the final management of long-lived, high- and medium-level radioactive waste. Three themes were then explored in more detail: local information, reversibility, environmental monitoring and memory of a long-term installation. Each theme was first addressed through a few brief presentations representing various viewpoints and sensibilities, and later discussed by all participants subdivided in small groups.

The workshop was assisted by the Local Committee for Information and Oversight (CLIS), a major actor in the French framework representing and informing all of civil society in the geographical area where a final disposal facility may be located. Logistic and financial support was provided by Andra, the national waste management agency which is a permanent member of the Forum on Stakeholder Confidence.

The NEA will publish the proceedings of the workshop in due course. They will include summaries of all stakeholder speeches and the outcomes of the discussions. The publication will serve to benchmark best practices and to archive history and progress to date. It should also become a useful document to distribute when receiving queries about relevant aspects of the French radioactive waste management programme.



FSC flyers and publications, including the proceedings of the events mentioned above and the programme of the French workshop, are made available at www.nea.fr/html/rwm/fsc.html. They will be of interest to all those dealing with socio-technical decision making. ■

News briefs

The RWMC Regulators' Forum

by C. Pescatore*

The NEA Radioactive Waste Management Committee Regulators' Forum (RWMC-RF) is a consolidated forum of senior regulators who have comprehensive views of the regulatory frameworks for radioactive waste management and decommissioning in NEA member countries. It provides regulators with opportunities for open discussions and exchanges of information on national regulatory experience and practices with a view to refining regulatory systems in this field. The RWMC-RF recognises the importance of effective interaction between regulators, implementers, policy makers and scientists, in order to reach a wider understanding of the issues associated with our responsibilities to present and future generations, and of the societal demands directly impacting the role of regulators in managing radioactive materials and waste.

On 20-22 January 2009 the RWMC-RF held its first of a series of workshops in an international context. Entitled "Towards Transparent, Proportionate and Deliverable Regulation for Geologic Disposal" the general purpose of the workshop was to address the questions of transparent, proportionate and deliverable regulation for long-term safety in as broad a fashion as possible. Subsidiary aims were to help the RWMC-RF and its partners:

- evaluate and update current regulatory positions, notably those adopted since the NEA Cordoba workshop of 1997, and add more recent developments/international guidance;
- complete the current understanding of the process for establishing long-term safety criteria and the major motivation for differences;
- establish areas of agreement/disagreement [e.g., duties to future generations, timescales for regulation, stepwise decision making, roles of optimisation and best available techniques (BAT), multiple lines of reasoning, safety and performance indicators and limitations, recognition of uncertainties, importance of stakeholder interactions, etc.];
- identify the elements of a successful process of regulation for the long term;
- carry out the first phase of an RWMC-RF project to study regulators' needs for research and development on regulatory-related issues.

The workshop was hosted by the Government of Japan through its Nuclear and Industrial Safety Agency (NISA), in co-operation with the Japan Nuclear Energy Safety Organisation (JNES).

Questions specific to the workshop had arisen from RWMC activities, including the reports on *Regulating the Long-term Safety of Geological Disposal* (OECD/NEA, 2007) and *Considering Timescales in the Post-closure Safety of Geological Disposal of Radioactive Waste* (OECD/NEA, 2009). In preparation of the workshop, the RWMC-RF carried out a survey of countries' regulatory positions that was provided with the workshop materials. Other workshop materials included a review of progress in regulation of geological disposal since the 1997 Cordoba workshop and a review of guidance in the field of optimisation of geological repositories. Overall, some 70 participants from 13 countries attended the workshop, including representation from the International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP).

Starting from a set of well-targeted questions, the workshop allowed a very broad exchange of views among participants, who represented not only regulatory authorities but also implementers of disposal facilities, policy makers and academics. The workshop methodology favoured discussions in small groups and all the participants were able to give their points of view and to share their experience with others. Speakers and participants at the closing session felt that the workshop accomplished its goals. The workshop proceedings are to be published later in 2009. Preliminary findings from the workshop are available in NEA/RWM/RF(2009)1. ■

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Calculating the cost of generating electricity: Which role for nuclear?

by J.H. Keppler*

Crisis or no crisis, between replacing ageing plants having reached the end of their economic life and keeping up with fast-rising demand, the world will need to invest roughly USD 15 trillion in electricity generation in the next 20 years. That is a large number even at the scale of the world economy. Each plant will have to be decided upon on the basis of a set of economic, social and environmental criteria.

Nuclear, coal, gas, hydro, other renewables… all have various advantages and disadvantages according to different customers and countries. Independent of the specific local and national context, however, economic and financial cost will frequently be the key criterion. Having an idea of the cost of different power plant technologies is thus crucial for developing a vision of the composition of the electricity sector in the years to come.

That is why the NEA, in co-operation with its sister agency the IEA, publishes an update approximately every five years of the cost of generating electricity with different technologies in a range of OECD countries. The last of these studies was published in 2005 under the title *Projected Costs of Generating Electricity*. These studies have always constituted highly respected reference values for the costs of power generation and figure regularly among the best-sellers of both the NEA and the IEA. Since the beginning of 2009, work on a new edition of the Electricity Generating Cost (EGC) study has begun.

The methodology employed for assessing the costs of different technologies is the calculation of levelised average lifetime costs. This means calculating the properly discounted lifetime costs of a plant according to a set of common assumptions and dividing it by its output, which provides an intuitive, easy-to-grasp cost figure per MWh of electricity. While such a figure certainly does not capture all the financially relevant aspects of a power plant, it constitutes a useful starting point for any discussion about investing in power generation. The most important assumptions used are the commissioning date (31 December 2015), the lifetime (40 years with sensitivity analyses for longer lifetimes) and the discount rate (5 and 10 per cent, again with sensitivity analyses for additional values).

While the basic methodology is relatively straightforward, its practical implementation is not. Power plants cannot be bought off a rack. Over a 40-year lifetime, many parameters, such as fuel prices, discount rates, contingency planning, refurbishment, waste handling and decommissioning, need to be assessed carefully by every participant contributing to the study. For this edition, not only the majority of NEA and IEA member countries are participating in the study, but also a number of renowned experts from industry and academia. Selected non-OECD countries will also send experts.

Traditionally, nuclear energy has been performing well in terms of levelised average lifetime costs, especially in locations with low interest rates. This cost advantage will be significantly enlarged if a) longer lifetimes are assumed, and b) carbon pricing with the help of carbon markets or a carbon tax becomes a reality. Carbon is, of course, already priced in Europe and is set to become so in the United States. In terms of financial performance, the disadvantage of nuclear energy remains its high ratio of fixed to variable costs, which implies increased investor risk in liberalised electricity markets with uncertain power prices.

In conjunction with generalised carbon pricing, however, the new generation 3+ reactors that will be commissioned now for 2015 should further improve the competitiveness of nuclear energy. The competitiveness of nuclear power plants should thus further increase to the extent that it can overcome the disadvantage of its cost profile, even in liberalised electricity markets. The 2010 edition of the Electricity Generating Costs study will show whether this is already the case. ■

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NEA joint projects:

nuclear safety, radioactive waste m

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 issues in the nuclear energy field. The projects are carried out under the auspices, and with the support, of the NEA. All NEA joint projects currently under way are listed below.

Project	Participants	Budget
Behaviour of Iodine Project (BIP) Contact: jean.gauvain@oecd.org Current mandate: July 2007-June 2010	Belgium, Canada, Finland, France, Germany, Japan, Netherlands, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States	≈€ 350 K /year
Cabri Water Loop Project Contact: radomir.rehacek@oecd.org Current mandate: 2000-2010	Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States	≈€ 74 million
Computer-based Systems Important to Safety (COMPSIS) Project Contact: jean.gauvain@oecd.org Current mandate: January 2008-December 2010	Chinese Taipei, Finland, Germany, Hungary, Republic of Korea, Sweden, Switzerland, United States	€ 80 K /year
Co-operative Programme on Decommissioning (CPD) Contact: patrick.osullivan@oecd.org Current mandate: January 2009-December 2013	Belgium, Canada, Chinese Taipei, France, Germany, Italy, Japan, Republic of Korea, Slovak Republic, Spain, Sweden, United Kingdom	≈€ 66 K /year
Fire Incidents Records Exchange (FIRE) Project Contact: jean.gauvain@oecd.org Current mandate: January 2006-December 2009	Canada, Czech Republic, Finland, France, Germany, Japan, Netherlands, Republic of Korea, Spain, Sweden, Switzerland, United States	≈€ 75 K /year
Halden Reactor Project Contact: radomir.rehacek@oecd.org Halden contact: Fridtjov.owre@hrp.no Current mandate: 2009-2011	Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Japan, Kazakhstan, Norway, Republic of Korea, Russian Federation, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States	≈€ 43 million
Information System on Occupational Exposure (ISOE) Contact: brian.ahier@oecd.org Current mandate: 2008-2011	Armenia, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Lithuania, Mexico, Netherlands, Pakistan, Republic of Korea, Romania, Russian Federation, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, United Kingdom, United States	≈€ 450 K /year

anagement, radiological protection

At present, 17 joint projects are being conducted in relation to nuclear safety, three in support of radioactive waste management, and one in the field of radiological protection. These projects complement the NEA programme of work and contribute to achieving excellence in each of the respective areas of research.

Objectives
• Provide separate effects and modelling studies of iodine behaviour in a nuclear reactor containment building following a severe accident. • Provide data and interpretation from three radioiodine test facility (RTF) experiments to participants for use in collaborative model development and validation. • Achieve a common understanding of the behaviour of iodine and other fission products in post-accident reactor containment buildings.
• Extend the database for high burn-up fuel performance in reactivity-induced accident (RIA) conditions. • Perform relevant tests under coolant conditions representative of pressurised water reactors (PWRs). • Extend the database to include tests done in the Nuclear Safety Research Reactor (Japan) on BWR and PWR fuel.
• 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. • Collect and analyse COMPSIS events over a long period so as to better understand such events, their causes and their prevention. • 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. • 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. • Record event attributes and dominant contributors so that a basis for national risk analysis for computerised systems is established.
• Exchange scientific and technical information amongst decommissioning projects for nuclear facilities.
• Collect fire event experience (by international exchange) in the appropriate format and in a quality-assured and consistent database. • Collect and analyse fire events data over the long term with the aim to better understand such events, their causes and their prevention. • 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. • 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. • 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: • extended fuel utilisation: basic data on how the fuel performs, both under normal operation and transient conditions, with emphasis on extended fuel utilisation in commercial reactors; • 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; • man-machine systems: advances in computerised surveillance systems, virtual reality, digital information, human factors and man-machine interaction in support of control room upgradings.
• Collect, analyse and exchange occupational exposure data and experience from all participants. • Provide broad and regularly updated information on methods to improve the protection of workers and on occupational exposure in nuclear power plants. • Provide a mechanism for dissemination of information on these issues, including evaluation and analysis of the data assembled and experience exchanged, as a contribution to the optimisation of radiation protection.

Project	Participants	Budget
International Common-cause Failure Data Exchange (ICDE) Project Contact: jean.gauvain@oecd.org Current mandate: April 2008-March 2011	Canada, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States	≈ € 110 K /year
Melt Coolability and Concrete Interaction (MCCI) Project Contact: jean.gauvain@oecd.org Current mandate: April 2006-December 2009	Belgium, Czech Republic, Finland, France, Germany, Hungary, Japan, Norway, Republic of Korea, Spain, Sweden, Switzerland, United States	€ 3.4 million
Piping Failure Data Exchange (OPDE) Project Contact: alejandro.huerta@oecd.org Current mandate: June 2008-May 2011	Canada, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United States	≈ € 50 K /year
PKL-2 Project Contact: jean.gauvain@oecd.org Current mandate: April 2008-September 2011	Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States	€ 3.9 million
PRISME Project Contact: carlo.vitanza@oecd.org Current mandate: January 2006-December 2010	Belgium, Canada, Finland, France, Germany, Japan, Netherlands, Republic of Korea, Spain, Sweden, United Kingdom, United States	€ 7 million
Rig of Safety Assessment (ROSA) Project Contact: carlo.vitanza@oecd.org Current mandate: April 2009-March 2012	Belgium, Czech Republic, Finland, France, Germany, Hungary, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States	€ 2.1 million
Sandia Fuel Project (SFP) Contact: carlo.vitanza@oecd.org Current mandate: June 2009-June 2012	Czech Republic, France, Germany, Hungary, Japan, Norway, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States	€ 4 million
SETH-2 Project Contact: jean.gauvain@oecd.org Current mandate: March 2007-December 2010	Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Slovenia, Sweden, Switzerland	€ 2.5 million
Sorption-3 Project Contact: patrick.osullivan@oecd.org Current mandate: November 2007-April 2010	Australia, Belgium, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Switzerland, United Kingdom, United States	€ 170 K /year

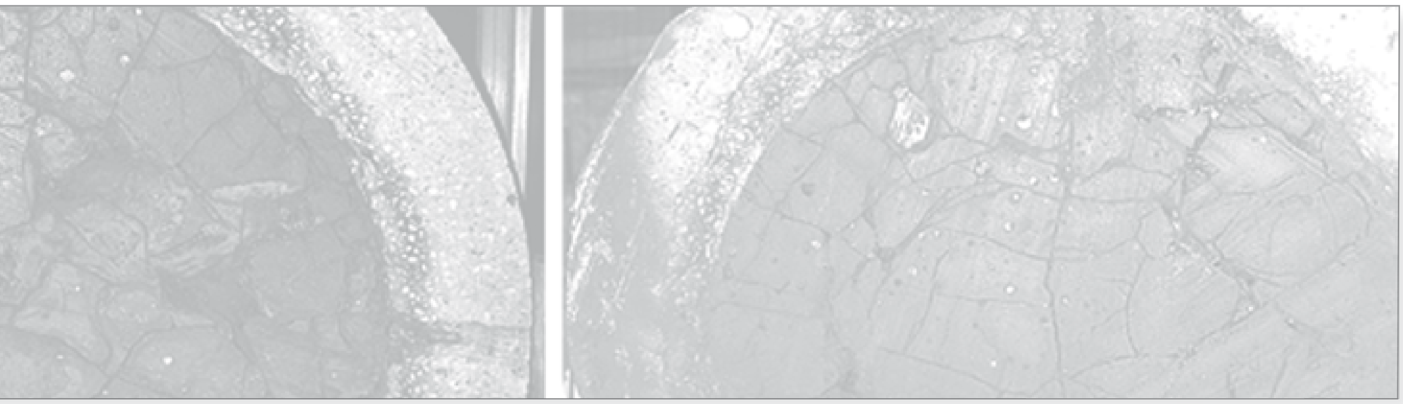
anagement, radiological protection

Objectives
• Provide a framework for multinational co-operation. • Collect and analyse common-cause failure (CCF) 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 CCF events which can then be 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 CCF phenomena, including the development of defences against their occurrence, such as indicators for risk-based inspections. • Generate quantitative insights and record event attributes to facilitate the quantification of CCF frequencies in member countries. • Use the ICDE data to estimate CCF parameters.
• Provide experimental data on melt coolability and concrete interaction (MCCI) severe accident phenomena. • Resolve two important accident management issues: – 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; – 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. • Generate qualitative insights into the root causes of piping failure events. • Establish a mechanism for efficient feedback of experience gained in connection with piping failure phenomena, including the development of defence against their occurrence. • 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 safety issues relevant for current PWR plants as well as for new PWR design concepts. • Focus on complex heat transfer mechanisms in the steam generators and boron precipitation processes under postulated accident situations.
• Answer questions concerning smoke and heat propagation inside a plant, by means of experiments tailored for code validation purposes. • Provide information on heat transfer to cables and on cable damage.
• 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. • 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/NEA member countries who share the need to maintain or improve technical competence in thermal-hydraulics for nuclear reactor safety evaluations.
• Address potential accident conditions and perform a highly detailed thermal-hydraulic characterisation of full-length, commercial pressurised water reactor (PWR) fuel assembly mock-ups. • Provide data for the direct validation of appropriate codes. • Address applicability to other fuel designs, also considering that BWR data will be made available to project participants.
• Generate high-quality experimental data that will be used for improving the modelling and validation of computational fluid dynamics (CFD) and lumped parameter (LP) computer codes designed to predict post-accident containment thermal-hydraulic conditions (for current and advanced reactor designs). • Address a variety of measured parameters, configurations and scales in order to enhance the value of the data for code applications. • Study relevant containment phenomena and separate effects, including effects of jets, natural convection, containment coolers and sprays.
• Demonstrate the potential of thermodynamic sorption models to improve confidence in the representation of radionuclide sorption in the context of radioactive waste disposal.

Project	Participants	Budget
Steam Explosion Resolution for Nuclear Applications (SERENA) Project Contact: jean.gauvain@oecd.org Current mandate: October 2007-September 2011	Canada, Finland, France, Germany, Japan, Republic of Korea, Slovenia, Sweden, Switzerland, United States	€ 2.6 million
Stress Corrosion Cracking and Cable Ageing (SCAP) Project Contact: akihiro.yamamoto@oecd.org Current mandate: June 2006-June 2010	Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Mexico, Norway, Republic of Korea, Slovak Republic, Spain, Sweden, Ukraine, United States	€ 480 K /year
Studsvik Cladding Integrity Project (SCIP) Contact: carlo.vitanza@oecd.org Current mandate: July 2009-June 2014	Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States	€ 7 million
Thermal-hydraulics, Hydrogen, Aerosols, Iodine (ThAI) Project Contact: jean.gauvain@oecd.org Current mandate: January 2007-December 2009	Canada, Czech Republic, Finland, France, Germany, Hungary, Netherlands, Republic of Korea, Switzerland	€ 930 K /year
Thermochemical Database (TDB) Project Contact: mireille.defranceschi@oecd.org Current mandate: 2008-2012	Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Republic of Korea, Spain, Sweden, Switzerland, United Kingdom, United States	≈€ 441 K /year

anagement, radiological protection

Objectives
• Provide experimental data to clarify the explosion behaviour of prototypic corium melts. • Provide experimental data for validation of explosion models for prototypic materials, including spatial distribution of fuel and void during the pre-mixing and at the time of explosion, and explosion dynamics. • Provide experimental data for steam explosions in more realistic, reactor-like situations to verify the geometrical extrapolation capabilities of the codes.
• Establish two complete databases on major ageing phenomena for stress corrosion cracking (SCC) and for degradation of cable insulation. • Establish a knowledge base by compiling and evaluating collected data and information systematically. • Perform an assessment of the data and identify the basis for commendable practices which would help regulators and operators to enhance ageing management.
• Assess material properties and determine conditions that can lead to fuel failures. • 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. • Achieve results of general applicability (i.e. not restricted to a particular fuel design, fabrication specification or operating condition). • Address LOCA issues by means of out-of-reactor testing.
• Address outstanding questions concerning the behaviour of hydrogen (combustion and removal using recombiners), iodine and aerosols (wall deposition, wash-out and interaction) in severe accident situations. • Improve understanding of the respective processes for evaluating challenges to containment integrity (hydrogen) and for evaluating the amount of airborne radioactivity during accidents with core damage (iodine and aerosols). • Generate data for evaluating the spatial distribution of hydrogen in the containment, its effective removal by means of equipment such as passive autocatalytic recombiners, and slow hydrogen combustion.
Produce a database that: • contains data for elements of interest in radioactive waste disposal systems; • documents why and how the data were selected; • gives recommendations based on original experimental data, rather than on compilations and estimates; • documents the sources of experimental data used; • is internally consistent; • treats all solids and aqueous species of the elements of interest for nuclear waste storage performance assessment calculations.



Obituaries

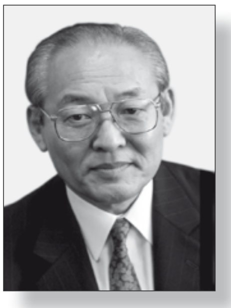
Mr. Howard K. Shapar, NEA Director-General, 1982-1988

Mr. Howard K. Shapar, former Executive Legal Director of the Nuclear Regulatory Commission (NRC) and former NEA Director-General, died on 15 March 2009 in Chevy Chase, Maryland. He was 85 years old.

Mr. Shapar graduated from Amherst College as valedictorian in 1947 and from Yale Law School in 1950. He began working for the Atomic Energy Commission (AEC) in Los Alamos, NM, and moved to Washington in 1962 to become the AEC's Assistant General Counsel for Licensing and Regulation. He played a key role in the 1970s in helping to establish an independent regulatory body in the United States by drafting the legislation that split the Atomic Energy Commission (AEC) into the Energy Research and Development Administration and the NRC. He subsequently became the Executive Legal Director of the NRC. In 1982, he was nominated Director-General of the NEA and served in this function until 1988. He returned to Washington in 1988 to join Shaw Pittman, a leading nuclear law firm, and Washington International Energy Group. He joined Egan, Fitzpatrick and Malsch in 2001 and retired in 2003. He received the Distinguished Service Award from the NRC. Mr. Shapar was a founder and past president of the International Nuclear Law Association.

Family members that survive him include his wife of 31 years, Henriette A.E. van Gerrevinck Shapar, and two children from his first marriage, Kristina and Stephen Shapar.

Dr. Kunihiko Uematsu, NEA Director-General, 1988-1995



Dr. Kunihiko Uematsu, senior advisor to the Japan Atomic Industrial Forum (JAIF) and former NEA Director-General, passed away on 28 April 2009 in Tokyo. He was 77 years old.

Dr. Uematsu obtained his doctorate from the Massachusetts Institute of Technology in 1961. Thereafter, he joined the Nuclear Fuel Corporation [predecessor to the Power Reactor and Nuclear Fuel Development Corporation (PNC)], and from 1996 to 1998 he served as Vice-President of PNC. He held the post of NEA Director-General from 1988 to 1995. He was a member of the Standing Advisory Group on Nuclear Energy at the International Atomic Energy Agency (IAEA) from 2000 to 2006, and became a member of the Nuclear Energy Advisory Committee (NEAC) of the US Department of Energy (DOE) in 2008. In 2007, he received the *Ordre national du Mérite (Officier)* for distinguished achievement from the French government.

Both Mr. Shapar and Dr. Uematsu will be greatly missed by their families, colleagues and friends.

New publications

Annual Report 2008

ISBN 978-92-64-99076-0. 48 pages. Free: paper or web.

Economic and technical aspects of the nuclear fuel cycle

Strategic and Policy Issues Raised by the Transition from Thermal to Fast Nuclear Systems

ISBN 978-92-64-06064-7. 84 pages. Price: € 40, US$ 54, £ 34, ¥ 5 000.

The renewed interest in nuclear energy triggered by concerns about global climate change and security of supply, which could lead to substantial growth in nuclear electricity generation, enhances the attractiveness of fast neutron reactors with closed fuel cycles. Moving from the current fleet of thermal neutron reactors to fast neutron systems will require many decades and extensive RD&D efforts. This book identifies and analyses key strategic and policy issues raised by such a transition, aiming at providing guidance to decision makers on the best approaches for implementing transition scenarios. The topics covered in this book will be of interest to government and nuclear industry policy makers as well as to specialists working on nuclear energy system analyses and advanced fuel cycle issues.

Nuclear safety and regulation

CSNI Technical Opinion Papers – No. 10

The Role of Human and Organisational Factors in Nuclear Power Plant Modifications

ISBN 978-92-64-99064-7. 28 pages. Free: paper or web.

Nuclear power plant modifications may be needed for a number of different reasons. These include physical ageing of plant systems, structures and components; obsolescence in hardware and software; feedback from operating experience; and opportunities for improved plant safety, reliability or capability. However, experience has also shown that weaknesses in the design and/or implementation of modifications can present significant challenges to plant safety. They can also have a considerable impact on the commercial performance of the plant. It is therefore important that the plant modification process reflect a recognition of the potential impact of human errors and that it incorporate suitable measures to minimise the potential for such errors.

In this context, the NEA Committee on the Safety of Nuclear Installations (CSNI) and its Working Group on Human and Organisational Factors organised an international workshop in 2003 to discuss the role of human and organisational performance in the nuclear plant modification process. This technical opinion paper represents the consensus of specialists in human and organisational factors (HOF) in the NEA member countries on commendable practices and approaches to dealing with nuclear plant modifications. It considers factors that should be taken into account when developing a modification process and identifies some lessons learnt from application of the process. The paper should be of particular interest to nuclear safety regulators and nuclear power plant operators.

CSNI Technical Opinion Papers – No. 11

Better Nuclear Plant Maintenance: Improving Human and Organisational Performance

ISBN 978-92-64-99065-4. 28 pages. Free: paper or web.

Errors during maintenance and periodic testing are significant contributors to plant events. These errors may not always be revealed by post-maintenance tests and may remain undetected for extended periods until the affected system is called upon to function. It is therefore important that the plant maintenance process take into account the potential impact of human and organisational errors, and that it incorporate suitable measures to minimise the potential for such errors.

The NEA Committee on the Safety of Nuclear Installations (CSNI) and its Working Group on Human and Organisational Factors organised an international workshop to discuss the role of human and organisational performance on maintenance. This technical opinion paper represents the consensus of specialists on human and organisational factors in NEA member countries on commendable practices and approaches to dealing with nuclear power plant maintenance. It sets out a framework for including a systematic consideration of human and organisational factors in the plant maintenance process. The paper should be of particular interest to nuclear safety regulators and nuclear power plant operators.

Improving Nuclear Regulation

Compilation of NEA Regulatory Guidance Booklets

ISBN 978-92-64-99075-3. 208 pages. Free: paper or web.

A common theme throughout the series of NEA regulatory guidance reports, or "green booklets", is the premise that the fundamental objective of all nuclear safety regulatory bodies is to ensure that nuclear facilities are operated at all times and later decommissioned in an acceptably safe manner. In meeting this objective the regulator must keep in mind that it is the operator that has responsibility for safely operating a nuclear facility; the role of the regulator is to oversee the operator's activities as related to assuming that responsibility.

For the first time, the full series of these reports has been brought together in one edition. As such, it is intended to serve as a knowledge management tool both for current regulators and the younger generation of nuclear experts entering the regulatory field. While the audience for this publication is primarily nuclear regulators, the information and ideas may also be of interest to nuclear operators, other nuclear industry organisations and the general public.

Radiological protection

Occupational Exposures at Nuclear Power Plants

Seventeenth Annual Report of the ISOE Programme, 2007

ISBN 978-92-64-99082-1. 120 pages. 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. ISOE provides experts in occupational radiological protection with a forum for communication and exchange of experience.

The programme includes 71 participating utilities in 29 countries (334 operating units and 45 shutdown units), as well as the regulatory authorities of 25 countries. The ISOE database, annual symposia and ISOE Network website facilitate the exchange of operational experience and lessons learnt among participants. The Seventeenth Annual Report of the ISOE Programme summarises occupational exposure data trends and ISOE achievements made during 2007. Principal developments in ISOE participating countries are also described. ISOE is jointly sponsored by the OECD Nuclear Energy Agency and the International Atomic Energy Agency (IAEA).

今日の世界における放射線防護：持続可能性に向けて

Japanese version of *Radiation Protection in Today's World: Towards Sustainability*

ISBN 978-92-64-99063-0. 72 pages. Free: paper or web.

Summary Report of the CRPPH 50th Anniversary Conference

Committee on Radiation Protection and Public Health (CRPPH), 31 May 2007

ISBN 978-92-64-99078-4. 48 pages. Free: paper or web.

The NEA Committee on Radiation Protection and Public Health (CRPPH) celebrated its 50th anniversary in May 2007. Taking advantage of its half century of experience, the Committee took this occasion to look forward towards the next 50 years in order to identify the most significant emerging challenges to radiological protection policy, regulation and application. This report summarises the presentations and discussions of the high-level regulators and international radiological protection organisations' leaders who attended, providing their views on how the radiological protection community can best move forward together to address emerging challenges.

The NEA Contribution to the Evolution of the International System of Radiological Protection

ISBN 978-92-64-99080-7. 122 pages. Free: paper or web.

Since the International Commission on Radiological Protection (ICRP) initiated a dialogue in 1999 on the evolution of the system of radiological protection, the NEA Committee on Radiation Protection and Public Health (CRPPH) has actively engaged in providing the ICRP with input and views. The Committee's work on this subject has included eight expert group reports, seven international conferences, and four detailed review and comment assessments of draft ICRP recommendations. This report presents a chronological summary of the issues, views and concerns raised by the CRPPH as the ICRP issued various draft versions of its new recommendations (ICRP Publication 103, published in December 2007), and of the response by the ICRP as seen in its subsequent draft recommendations. The interest of this summary report is that it will not only assist readers in understanding the main themes and concepts of the new ICRP recommendations, but also why and how the changes from the previous ICRP Publication 60 recommendations came about.

Radioactive waste management

Considering Timescales in the Post-closure Safety of Geological Disposal of Radioactive Waste

ISBN 978-92-64-06058-6. 160 pages. Price: € 40, US$ 54, £ 34, ¥ 5 000.

A key challenge in the development of safety cases for the deep geological disposal of radioactive waste is handling the long time frame over which the radioactive waste remains hazardous. The intrinsic hazard of the waste decreases with time, but some hazard remains for extremely long periods. Safety cases for geological disposal typically address performance and protection for thousands to millions of years into the future. Over such periods, a wide range of events and processes operating over many different timescales may impact on a repository and its environment. Uncertainties in the predictability of such factors increase with time, making it increasingly difficult to provide definite assurances of a repository's performance and the protection it may provide over longer timescales. Timescales, the level of protection and the assurance of safety are all linked.

Approaches to handling timescales for the geological disposal of radioactive waste are influenced by ethical principles, the evolution of the hazard over time, uncertainties in the evolution of the disposal system (and how these uncertainties themselves evolve) and the stability and predictability of the geological environment. Conversely, the approach to handling timescales can affect aspects of repository planning and implementation including regulatory requirements, siting decisions, repository design, the development and presentation of safety cases and the planning of pre- and post-closure institutional controls such as monitoring requirements. This is an area still under discussion among NEA member countries. This report reviews the current status and ongoing discussions of this issue.

Natural Tracer Profiles Across Argillaceous Formations: The CLAYTRAC Project

ISBN 978-92-64-06047-0. 364 pages. Price: € 75, US$ 101, £ 63, ¥ 3 900.

Disposal of high-level radioactive waste and spent nuclear fuel in engineered facilities, or repositories, located deep underground in suitable geological formations is being developed worldwide as the reference solution to protect humans and the environment both now and in the future. An important aspect of assessing the long-term safety of deep geological disposal is developing a comprehensive understanding of the geological environment in order to define the initial conditions for the disposal system as well as to provide a sound scientific basis for projecting its future evolution. The transport pathways and mechanisms by which contaminants could migrate in the surrounding host rock are key elements in any safety case. Relevant experiments in laboratories or underground test facilities can provide important information, but the challenge remains in being able to extrapolate the results to the spatial and temporal scales required for performance assessment, which are typically tens to hundreds of metres and from thousands to beyond a million years into the future. Profiles of natural tracers dissolved in pore water of argillaceous rock formations can be considered as large-scale and long-term natural experiments which enable the transport properties to be characterised.

The CLAYTRAC Project on Natural Tracer Profiles Across Argillaceous Formations was established by the NEA Clay Club to evaluate the relevance of natural tracer data in understanding past geological evolution and in confirming dominant transport processes. Data were analysed for nine sites to support scientific understanding and development of geological disposal. The outcomes of the project show that, for the sites and clay-rich formations that were studied, there is strong evidence that solute transport is controlled mainly by diffusion. The results can improve site understanding and performance assessment in the context of deep geological disposal and have the potential to be applied to other sites and contexts.

Regulating the Decommissioning of Nuclear Facilities

Relevant Issues and Emerging Practices

ISBN 978-92-64-99059-3. 84 pages. Free: paper or web.

The removal of fuel from a permanently shutdown nuclear facility eliminates the major source of radiological hazard, a nuclear criticality. Combined with the cessation of operations at high temperatures and pressures, the risk to public health and to the environment is thereby very significantly reduced. The process of decommissioning does however necessitate processes involving both conventional and radiological hazards such as the cutting and dismantling of structures, plant and equipment and the use of explosive cutting techniques. Some radiological hazards remain because of the possibility of coming into contact with radioactively contaminated or activated material. This report considers how regulatory arrangements are being adapted to the continuously changing environment, and associated risk levels in a nuclear facility that is being decommissioned. It uses examples of current practices in several countries with large decommissioning programmes to illustrate emerging regulatory trends.

Release of Radioactive Materials and Buildings from Regulatory Control

A Status Report

ISBN 978-92-64-99061-6. 72 pages. Free: paper or web.

The radiological concept of clearance can be defined as the release of radioactive materials or buildings from any further regulatory control applied for radiological protection purposes by the competent body. It is generally based on the assumption that, following clearance, any potential radiological exposure of the public will be trivial. Clearance is now a mature concept being used for the management of large amounts of radioactive materials (including metals, building rubble, cables and plastics) and disused buildings associated with a controlled nuclear activity. There are, however, differences in the ways in which clearance is dealt with in the regulatory frameworks of various countries and the ways in which clearance has been implemented in diverse decommissioning projects. This report provides up-to-date information on an array of national approaches to clearance. It should be of particular help to those planning the implementation of a clearance procedure, such as that for decommissioning a nuclear facility.

Stability and Buffering Capacity of the Geosphere for Long-term Isolation of Radioactive Waste: Application to Crystalline Rock

Workshop Proceedings, Manchester, United Kingdom, 13-15 November 2007

ISBN 978-92-64-06056-2. 304 pages. Price: € 65, US$ 87, £ 55, ¥ 8 100.

Geological settings selected as potential host formations for the deep geological disposal of radioactive waste are chosen for, among other assets, their long-term stability and buffering capacity against disruptive or destabilising events and processes. The NEA Integration Group for the Safety Case organised a workshop on geosphere stability to develop a better understanding of the scientific evidence and arguments that contribute to confidence in the geological stability for deep geological disposal.

These proceedings present the outcomes of a geosphere stability workshop, held in November 2007, that focused on crystalline and other types of hard, fractured rocks. The workshop underscored the fact that many such rocks are intrinsically stable environments that evolve extremely slowly and provide good buffering against external events and processes. There is a good understanding of the processes and events that can affect crystalline rocks and, although there is less confidence in predicting exactly when and where such events will occur and the volume of rock that will be affected, the extent of the impacts on a geological repository can be confidently addressed using bounding approaches supported by geological information from similar sites around the world.

Nuclear law

Nuclear Law Bulletin

ISSN 0304-341X. 2009 subscription: € 114, US$ 150, £ 79, ¥ 16 500.

Considered to be the standard reference work for both professionals and academics in the field of nuclear law, the *Nuclear Law Bulletin* is a unique international publication providing its 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.

Nuclear science and the Data Bank

Chemical Thermodynamics of Thorium – Volume 11

ISBN 978-92-64-05667-1. 942 pages. Price: € 175, US$ 248, £ 136, ¥ 26 200.

This volume is the eleventh in the OECD Nuclear Energy Agency (NEA) “Chemical Thermodynamics” series. It is based on a critical review of the thermodynamic properties of thorium, its solid compounds and aqueous complexes, initiated as part of the NEA Thermochemical Database Project Phase III (TDB III). The database system developed at the OECD/NEA Data Bank ensures consistency not only within the recommended data sets of thorium, but also amongst all the data sets published in the series. This volume will be of particular interest to scientists carrying out performance assessments of deep geological disposal sites for radioactive waste.

Mobile Fission and Activation Products in Nuclear Waste Disposal

Workshop Proceedings, La Baule, France, 16-19 January 2007

ISBN 978-92-64-99072-2. 264 pages. Free: paper or web.

Most experts worldwide agree that disposal of spent nuclear fuel in appropriate formations deep underground provides a suitable option. Most public discussions about these underground repositories concentrate on the radiological hazard associated with the potential leak of actinides to the biosphere. However, the radiotoxicity of the fission products dominates the total radiotoxicity of the spent nuclear fuel during the first 100 years. Thereafter, their radiotoxicity diminishes and the long-term radiotoxicity becomes dominated by the actinides, mainly by the plutonium and americium isotopes.

The aim of the international workshop on Mobile Fission and Activation Products in Nuclear Waste Disposal, MOFAP07, was to review and to identify the needs for further studies on the transport and chemical behaviour of fission products in the geosphere for the safety assessment of radioactive waste repositories. These proceedings contain 22 peer-reviewed papers from the workshop, which should be of particular interest to professionals in the radioactive waste management field.

Nuclear Fuel Cycle Transition Scenario Studies

Status Report

ISBN 978-92-64-99068-5. 124 pages. Free: paper or web.

Future nuclear fuel cycles could effectively address radioactive waste issues with the implementation of partitioning and transmutation (P&T). Previous studies have defined the infrastructure requirements for several key technical approaches. While these studies have proven extremely valuable, several countries have also recognised the complex, dynamic nature of the infrastructure problem: severe new issues arise when attempting to transit from current open or partially closed cycles to a final equilibrium or burn-down mode. While the issues are country-specific when addressed in detail, it is believed that there exists a series of generic issues related only to the current situation and to the desired end point. These issues are critical to implementing a sustainable nuclear energy infrastructure. The present report focuses on the definition of key issues, the assessment of technologies and national scenario assessments.

PENELOPE-2008: A Code System for Monte Carlo Simulation of Electron and Photon Transport

Workshop Proceedings, Barcelona, Spain, 30 June-3 July 2008

ISBN 978-92-64-99066-1. 336 pages. Free: paper or web.

Radiation is used in many applications of modern technology. However, its proper handling requires competent knowledge of the basic physical laws governing its interaction with matter. To ensure its safe use, appropriate tools for predicting radiation fields and doses, and subsequently establishing pertinent regulations, are required. One area of radiation physics that has received much attention concerns electron-photon transport in matter. PENELOPE is a modern, general-purpose Monte Carlo tool for simulating the transport of electrons and photons, which is applicable for arbitrary materials and in a wide energy range. PENELOPE provides quantitative guidance for many practical situations and techniques, including electron and X-ray spectroscopies, electron microscopy and microanalysis, biophysics, dosimetry, medical diagnostics and radiotherapy, and radiation damage and shielding. These proceedings contain the extensively revised teaching notes of the latest workshop/training course on PENELOPE (version 2008), along with a detailed description of the improved physics models, numerical algorithms and structure of the code system.

The JEFF-3.1.1 Nuclear Data Library

JEFF Report 22 - Validation Results from JEF-2.2 to JEFF-3.1.1

ISBN 978-92-64-99074-6. 62 pages. Free: paper with CD-ROM or web.

The JEFF-3.1.1 library is an updated version of the JEFF-3.1 Joint Evaluated File for Fission and Fusion. It consists of sets of evaluated nuclear data for reactor applications. Reliable data of this sort are necessary to improve the safety and economy of existing installations, as well as for the design and efficient operation of advanced nuclear reactors. The improvements in this latest version of the JEFF-3.1.1 library are particularly noteworthy as regards light water reactor applications and the associated fuel cycle. The present report provides detailed information on the analysis and incremental validation process employed with regard to the JEF-2.2 library, which has provided the basis for the JEFF-3.1.1 library.

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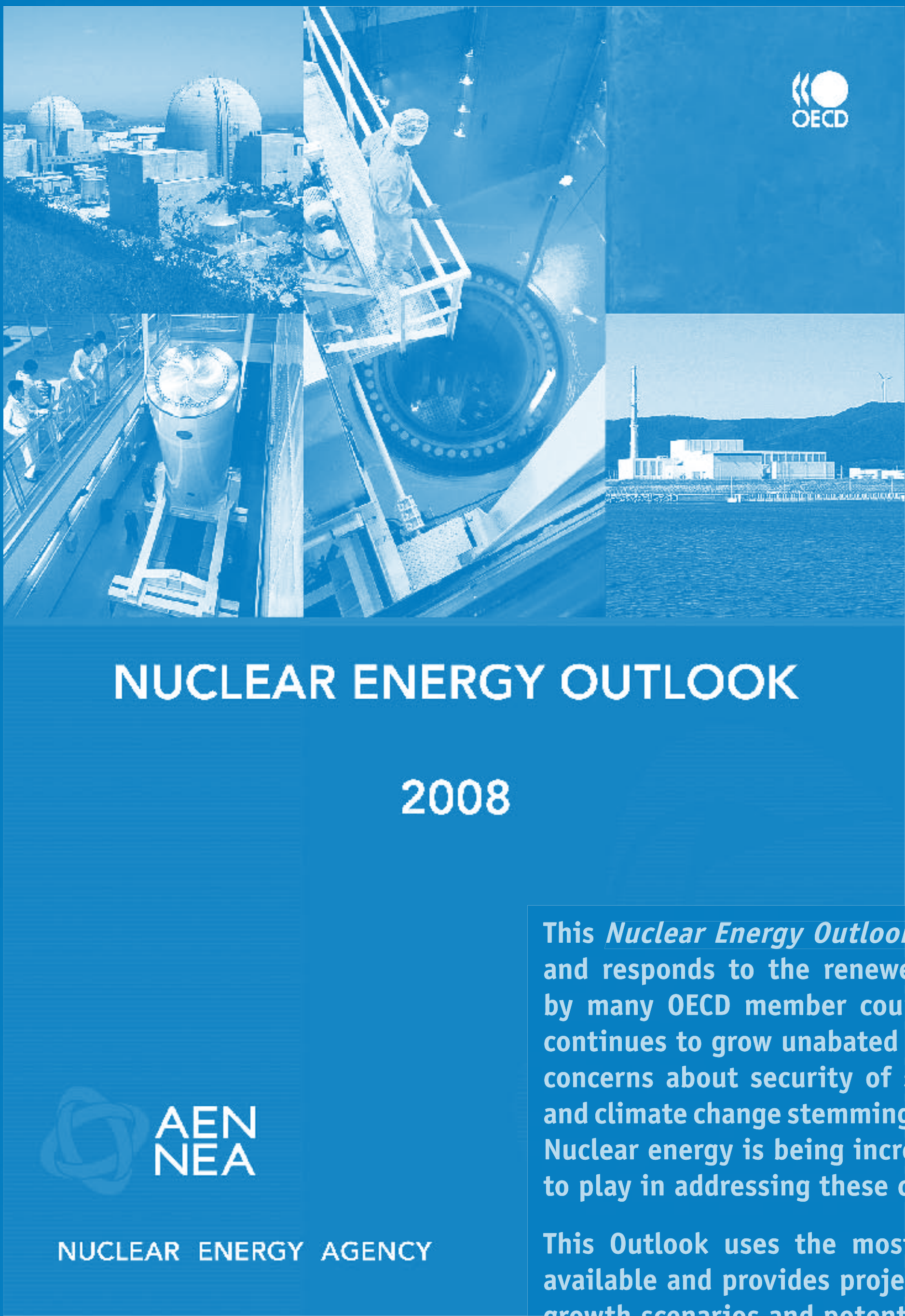
Nuclear Energy Outlook 2008

ISBN 978-92-64-05410-3. 460 pages. Price: € 105, US$ 161, £ 81, ¥ 16 800.



This *Nuclear Energy Outlook* (NEO) is the first of its kind and responds to the renewed interest in nuclear energy by many OECD member countries. World energy demand continues to grow unabated and is leading to very serious concerns about security of supply, soaring energy prices and climate change stemming from fossil fuel consumption. Nuclear energy is being increasingly seen as having a role to play in addressing these concerns.

This Outlook uses the most current data and statistics available and provides projections up to 2050 to consider growth scenarios and potential implications on the future use of nuclear energy. It also offers unique analyses and recommendations on the possible challenges that lie ahead.

Topics covered by the NEO include nuclear power's current status and projected trends, environmental impacts, uranium resources and security of supply, costs, safety and regulation, radioactive waste management and decommissioning, non-proliferation and security, legal frameworks, infrastructure, stakeholder engagement, advanced reactors and advanced fuel cycles.

Order information on page 37.

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