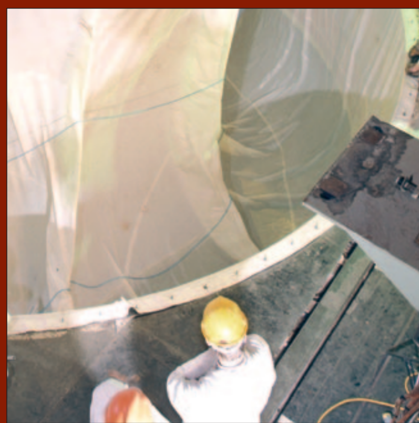
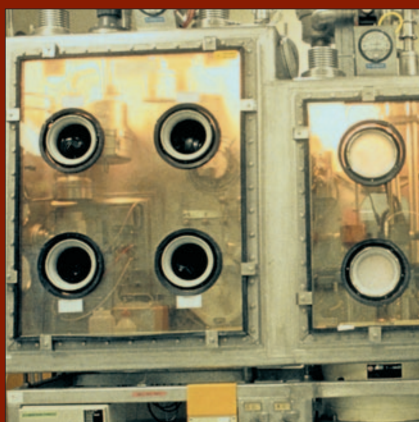
NEA News

2004 – No. 22.2

In this issue:





AEN
NEA

NUCLEAR • ENERGY • AGENCY

NEA News

2004
No. 22.2

NEA News is published twice yearly in English and French by the OECD Nuclear Energy Agency. The opinions expressed herein are those of the contributors alone and do not necessarily reflect the views of the Organisation or of its member countries. The material in *NEA News* may be freely used provided the source is acknowledged.

All correspondence should be addressed to:

The Editor, NEA News
OECD Nuclear Energy Agency
12, boulevard des Îles
92130 Issy-les-Moulineaux
France
Tel.: +33 (0) 1 45 24 10 10
Fax: +33 (0) 1 45 24 11 10

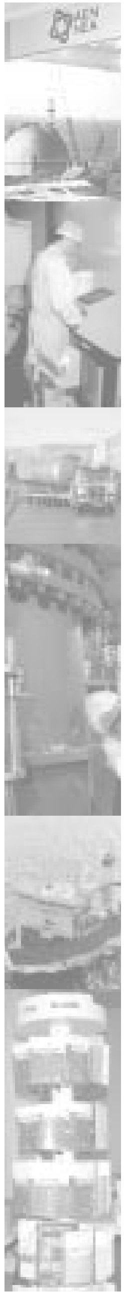
The OECD Nuclear Energy Agency (NEA) is an intergovernmental organisation established in 1958. Its primary objective is to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally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

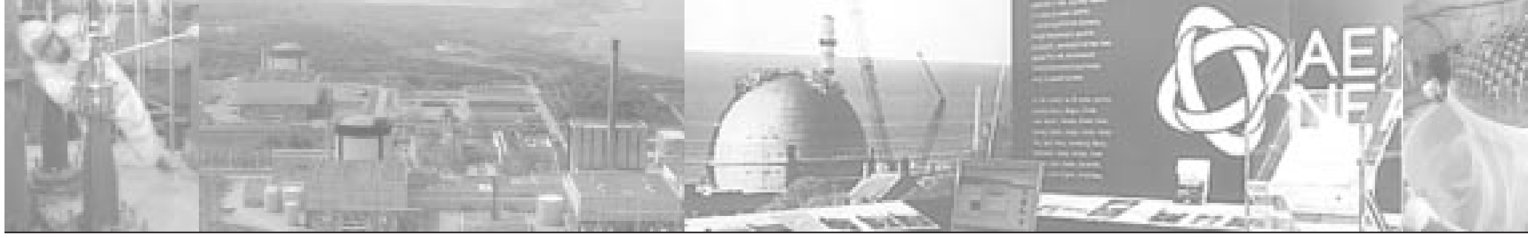
For more information about the NEA, see:

www.nea.fr

Cover page: Decommissioning at Windscale (UKAEA, United Kingdom), aerial view of Ringhals NPP (Ringhals AB, Sweden), research at Marcoule (Foulon, CEA, France).

Contents





Nuclear energy brought to the fore

Since the last issue of NEA News*, several energy policy discussions have taken place around the world in which the role of nuclear energy was brought to the fore. At these events, considerable change could be noted in the approach of many groups, and a few events merit special mention.*

The first was the World Energy Congress (WEC) which took place in Sydney, Australia in September. I noted there that the security of energy supply, in terms of both availability of resources and affordable prices, as well as the protection of the environment, notably from climate change, were driving many to reassess their policies and to consider all energy options, including nuclear. Throughout the Congress and at the session I chaired on "Nuclear Energy – Inevitable or Irrelevant?", participants were considering the nuclear option with more interest than has been seen in the past two decades.

At the opening plenary of the American Nuclear Society (ANS) winter meeting held in Washington D.C. on "Nuclear in the 21st Century – Going Forward Together", OECD Secretary-General Donald Johnston underlined the importance of combating climate change and the role that nuclear energy could play. Other speakers highlighted the role of decision makers within the nuclear community and their support of nuclear energy through research, design and management activities.

Planned expansion of nuclear power programmes in several Asian countries has been moving forward steadily. New developments are now also beginning to surface elsewhere. For example, Finland and France are preparing to construct additional capacity, while the Nuclear Power 2010 programme in the United States is taking on more concrete form. A sizable group of countries with nuclear power programmes is also working to develop the next generation of nuclear reactors through the Generation IV International Forum (GIF).

Against this backdrop, the NEA continues its efforts to provide strong scientific, economic and technological studies to support decision making in the nuclear energy field. This issue of NEA News *reflects a few of the areas of research of particular interest to NEA member countries, including the safety of nuclear installations, stakeholder participation in radioactive waste management and safe, efficient and cost-effective decommissioning.*

Luis E. Echávarri
NEA Director-General

Knowledge management and the elephant

G. H. Marcus *

Knowledge management has come to mean many things to different groups of people, even within a single industry or sector. Its various aspects are wide-ranging and not easily brought together under a single roof. This article provides an initial glimpse into what is at stake and how the NEA is playing a role in the process.

Discussing knowledge management sometimes reminds me a little of the parable of the blind men and the elephant – or, if I may be politically correct, of the visually challenged people and the elephant. In this story, a number of sightless men approach an elephant and touch it in different places. "Ah," says the first, who is touching the elephant's massive leg, "An elephant looks like a tree." "No," objects the second, who is holding the ear, "The elephant is clearly like a giant fan." "Come, come," chides a third, who has grabbed the elephant by its trunk, "The elephant most resembles a snake." Others, touching the side of the animal conclude it is like a wall, or feeling the tusk believe it resembles a spear, or grasping the tail likens it to a rope.[1]

Likewise, in my discussions on knowledge management (KM), I come away with a sense that different nuclear communities have somewhat different perceptions of what it is, and therefore, of what the issues or problems are. For educators, KM is education, and the most important need is to develop the right academic courses to train the next generation of nuclear professionals. Corporate management sees KM in terms of its strategic market advantages, and considers the passing on of corporate knowledge a major need. In some parts of the industry, nuclear training is also an important concern. The research community sees the closure of research facilities and the cancellation of research projects midstream and worries about the loss of the data collected from past experiments and the undocumented knowledge of the original researchers.

Of course, I draw a slightly extreme picture. Most of us understand the multiple dimensions to nuclear knowledge. However, different parts of the community do define KM somewhat differently, and different parts of the community do have a different sense of what actions are most critical, and therefore, on where resources should be spent.

Renewed interest in nuclear power

The time is ripe for the nuclear community to revisit how it has managed knowledge and to refine its activities for the future. Worldwide, there is a renewed interest in the nuclear power option. With the exploration of advanced reactor technologies comes the need to consider the use of research already done. (Changes to current operating facilities, through and including the decommissioning of such facilities, also draw on old data and design decisions.)

Several international programmes have been put in place to

* *Dr. Gail H. Marcus (e-mail: gail.marcus@oecd.org) is Deputy Director-General at the NEA.*

address the technological and other issues associated with a new generation of nuclear power plants. The Generation IV International Forum (GIF) is bringing together the research efforts of a number of countries to allow the sharing of facilities, financial resources and expertise to look into the next generation of reactors and research facilities. The IAEA International Project on Innovative Reactors and Fuel Cycles (INPRO) is also considering issues associated with new reactors.

Academic programmes in several countries are rebounding after a number of years of decline. Enrolments in nuclear programmes are increasing, and several new university programmes have been started. In addition, some very promising regional academic networks have been initiated: the Asian Network of Education in Nuclear Technology (ANENT), the European Nuclear Education Network (ENEN), the University Network of Excellence in Nuclear Engineering (UNENE) in Canada, and most recently, the World Nuclear University (WNU).

The NEA role

In this environment, the NEA is beginning to explore with its committees how it may be able to help member countries with KM activities. On the surface, it seems a bit strange for the NEA to be talking about KM as a "new" area of activity. After all, at its very core, what the NEA deals with is knowledge. Throughout its history, the NEA has played a significant role in all of the elements traditionally associated with nuclear knowledge – its generation, analysis, documentation, dissemination, preservation and transmission. Some highlights include the following:

In the area of education:

- The NEA continues its highly successful International School of Nuclear Law at the University of Montpellier in France.
- This year, upon request, the NEA held a specialised course on nuclear law and protection of the environment at the University of Cluj-Napoca in Romania.
- The NEA has been co-operating with the WNU effort since its inception and has committed to make its nuclear law courses available as part of future WNU activities.

In the area of data management and preservation:

- The NEA Data Bank has long operated as an international centre for code development and verification, and as a repository for data and analytical studies.
- The NEA works co-operatively with other data centres, such as the Oak Ridge National Laboratory Radiation Safety Information Computational Center (RSICC) in the United States.
- The NEA is also involved in efforts in selected areas, such as in the review and evaluation of data from past criticality safety benchmarking experiments.

In the area of new knowledge generation:

- The NEA serves as the Secretariat for the GIF technical working groups, which are developing research programmes for advanced reactor concepts.
- The NEA continues to play a co-ordinating role for international research projects such as the Halden Project.
- The NEA has conducted a study exploring opportunities for international co-operation in innovative nuclear reactor development.

In the area of knowledge dissemination:

- The NEA continues its active role in adding to the literature authoritative studies and analyses ranging from highly technical areas to broad policy questions.
- The NEA continues to sponsor or cosponsor a variety of conferences, symposia, seminars and workshops, some aimed at a very broad community, and others focused on the needs in very specific technical areas.

Of course, the task of *managing* nuclear knowledge activities appropriately is always an evolving one. Renewed research on advanced technologies creates new pressures to address the disposition of old research archives. New operating facilities will undoubtedly generate increased demands for educated and trained personnel. Further, it appears that there may be lessons to be learned from the past. Clearly, the abandonment of research (due to precipitous funding changes) without fully documenting what had been done and why is one of the unfortunate mistakes of the past.

Beyond its own activities in KM, the NEA can assist member countries in their initiatives as well. One of the Agency's early efforts will be to get a better sense of the full range of KM activities taking place in various countries, and the Secretariat will be working with the NEA committees to accomplish this task. The NEA can also usefully help countries share best practices in KM and, upon request can serve as a repository for data, codes and analyses.

The one caution that is on the mind of everyone who is interested in KM is that the

In participating in a variety of conferences, symposia, seminars and workshops, the NEA plays a significant role in all of the elements traditionnally associated with nuclear knowledge

- Education
- Data management and preservation
- New knowledge generation
- Knowledge dissemination

resources for this activity are limited. For example, new facilities are needed, but they are expensive, and we can no longer expect to duplicate expensive research facilities on every campus and in every country. Better sharing of such scarce resources is needed, both within the larger countries and across national borders. The strong interest in international collaboration on research projects is therefore very promising. However, there are still many hurdles ahead when it comes to siting new facilities, as the ITER experience in the fusion area suggests.

Further, there may be useful data available from old experiments, but the analysis of this data will draw from the same pool of funding that is available for new research. Intelligent decisions need to be made to determine which portions of the old data merit being retrieved and analysed. This requires tough choices based on a combination of factors, such as technologies of current interest, availability of research facilities and capabilities for new work, and the state of preservation of old data. A lesson learnt for the future is to try to craft funding and research performance so that research programmes complete and document the analysis of data already collected, even when research priorities change. A number of NEA committees have addressed portions of the data preservation issue by developing guidelines in specific areas. The Agency will be looking to share those guidelines for expanded use.

Given that KM is threaded through everything the NEA does, it is unlikely that there will be a specific new initiative for KM. Rather, it is likely to become a horizontal activity, with initiatives and practices already under way shared across committees and activities. While that may look very much on the surface like "business as usual", we believe that a cross-cutting initiative can help focus and strengthen existing activities with very little new effort needed. The outcome of this approach will be improved consistency across NEA activities, and hopefully, across the activities of NEA member countries as well. ■

Note

1. There are several versions of this story. These examples are drawn from a poem, "The Blind Men and the Elephant", by American poet John Godfrey Saxe (1816-1887). The idea behind the poem derives from India, and several sources have been cited for its origin.

Dose constraints: What are they now?

T. Lazo *

The evolution of social and risk governance that accelerated in the early 1990s has had profound effects on radiological protection. Motivated by these social developments, in 1999 the International Commission on Radiological Protection (ICRP) began drafting new general recommendations on the key principles and precepts of radiological protection. The concept of dose constraints, in particular, has changed considerably.

The ICRP has recently completed a draft of revised recommendations on radiological protection, the first such revision in more than a decade. The key principles in its latest draft material were presented as RP05 at the IRPA-11 Conference in May 2004 and posted on the ICRP website for comment in June, with expected approval in mid-2005. They have been found to differ significantly from previous recommendations.

This article reviews the new concept of dose constraints as compared with the 1990 ICRP Publication 60 description[1], and points out the nature of the differences that now exist between the old and the new as a result of the concept's evolution. It also presents some ideas on how the new concept might be implemented in a coherent fashion.

Dose constraints according to Publication 60

The concept of dose constraints was introduced in Publication 60 as a means to ensure that the radiological protection optimisation process did not "create inequities". Here, "inequities" refers to the possibility that some individuals in an optimised protection scheme may be subject to much more exposure than the average. An example of this would be to use a small number of workers for a task, with each getting a relatively high dose, rather than a larger number of workers each getting smaller doses. This concept is presented in paragraph 121 of Publication 60.

In general, Publication 60 characterises dose constraints as:

- *only* applying to situations that are under control, called "practices";
- being numerically less than dose limits;
- being established by national authorities;
- having numerical values that are based on exposures that can be incurred in "well-managed operations", for occupational exposures, and based on fractions of the public dose limit depending upon the number of sources to which a critical group is exposed;
- limited to 20 mSv per year for occupational dose constraints;
- less than 1 mSv per year for the public.

This concept in Publication 60 is distinct from that of the protection of workers or the public in the case of accidents or already-existing situations. In these cases, the ICRP suggests the establishment of "reference levels", *above* which some remedial actions should be considered (§257). In the case of emergency situations,

** Dr. Ted Lazo (e-mail: lazo@nea.fr) works in the NEA Radiation Protection and Radioactive Waste Management Division.*

these are called intervention levels (§221). In the case of existing situations, such as exposure to radon, they are called action levels (§217). Below these reference levels, the Commission suggests that, in general, no protective actions would be needed.

Dose constraints in the new draft ICRP recommendations

Following criticisms that the Publication 60 recommendations are somewhat incoherent, and in order to simplify and consolidate its recommendations, the Commission has now established in RP05 that *all* exposure situations will be conceptually addressed through the process of constrained optimisation. This means that dose constraints will be established for situations that are under control (formerly called practices), as well as for accident situations and existing situations (formerly called interventions). In all of these situations, a dose constraint is established above which exposures should not be allowed, and below which there should be optimisation. Exceeding these dose constraints would be considered as a *failure*, as explained in paragraphs 132 and 133 of RP05.

This is a significant change from the Publication 60 concept of dose constraints for several reasons. In its Publication 60 recommendations, the Commission considered, at least implicitly, that dose limits were the most significant regulatory tool for the measurement of compliance. In RP05, exceeding a dose constraint (considered as a failure) will be the main indicator of non-compliance with regulatory requirements.

The new recommendation proposes that, in *any* situation, there can be a pre-defined exposure level above which exposures should not be allowed. Publication 60 distiguishes two main types of situation. It considers that in "controlled", predictable situations, exposures can be actively controlled and limited, by regulation, to remain below a pre-defined value. In situations where doses could not be inherently prevented, such as an accident or a pre-existing situation due to natural exposures (i.e. radon), it is seen as practically impossible to predefine a regulatory dose level above which individuals should not be exposed. As such, intervention levels have been recommended, above which some action would be considered. Now, the Commission suggests that regulatory dose levels can be established in *all* situations such that planning, preparations and protective actions can be undertaken to effectively prevent individuals exceeding this pre-defined dose constraint. This can be used as a planning tool, as well as a retrospective tool for compliance.

These changes are seen by many as being a significant deviation from previous ICRP philosophy. In particular, if exceeding a constraint is defined as a failure, regulatory organisations might interpret dose constraints more as limits for compliance enforcement. As such, with the dose constraints being defined as no higher than a dose limit (in situations where limits are applicable), regulatory requirements could become more strict. However, there is no new scientific evidence for such an effective lowering of exposure limits.

Moreover, the previous dose constraints used to regulate intervention situations were built around establishing some sort of reference levels above which taking action should be considered, and below which action would most likely not be needed. National regulatory agencies and international organisations have since established their regulations and standards on this basis. Now, changing to a concept of an "upper boundary", applicable to all situations and below which optimisation should be performed, could require significant regulatory and procedural change as well as a change of "mindset" for regulators and implementers alike.

A possible approach to implementation

Yet, would the implementation of this approach really change the implementation of radiological protection? Under the Publication 60 approach, optimisation is required in all situations.

For practices, this has meant the use of limits and constraints and the obligation to optimise protection below these values such that residual doses are as low as reasonably achievable (ALARA). This approach is the same whether using the Publication 60 philosophy or the new philosophy.

For interventions in accident situations, this has meant that the nature and duration of the intervention must be optimised to avert as much dose as reasonably achievable, that is, to prevent as much dose as possible when compared with not intervening. So, practically speaking, optimisation is again required.

For example, when predicted exposures begin to approach levels that would result in deterministic effects, intervention is required to prevent these exposures. This is, in effect, the establishment of a practical upper bound below

P. Bérenger, EDF, France

The application of worker protection takes on many forms.

which optimisation is required. A similar argument has been implicitly used with regard to "significant" risk of stochastic effects when fixing intervention levels for evacuation or sheltering or the use of stable iodine. Even at lower exposures, the obligation to optimise would generally result in protection solutions that avert more dose than suggested by the intervention level, thus effectively taking action *below* the intervention level, as is suggested by the new concept.

When considering protection against exposure in existing situations, such as radon in homes, this same argument applies. The Publication 60 approach has generally led national regulatory authorities to establish a level above which some actions to reduce exposures would become increasingly necessary. The new concept suggests that national regulatory authorities should use the ICRP-recommended dose constraint as an upper bound to then perform a generic optimisation to establish a level below which dose reduction actions would not generally be considered necessary. The result of both approaches, in application, is then the same.

So, the approach proposed in RP05 seems to have some advantages:

- A single approach to situations is easier to understand and to explain.
- The process is inherently driven by stakeholder involvement, at an appropriate level and with appropriate stakeholders.
- The process is inherently flexible in that it is based on optimisation, and optimisation ends when the stakeholders agree on optimum protection so that appropriate solutions accounting for local considerations can be developed.

Practical application choices will be the key

The choice of numerical values for the new dose constraints is nevertheless a practical concern. As said earlier, the lack of new scientific evidence to change our current understanding of radiation risks suggests that there is no justification for tightening regulatory controls of exposures. However, particularly for controllable situations, with many public statements being made that constraints should be less than regulatory limits, it is feared that occupational exposures could be constrained at a level *below* 20 mSv per year, and that public exposures could be constrained at below 1 mSv per year.

It may also be noted that some concern has been voiced regarding the inherent loss of flexibility that would result if an occupational dose constraint of 20 mSv per year were to replace the current approach of dose limits set at 100 mSv over five years, not to exceed 50 mSv in any single year. The practical application of the new recommendations by national regulatory authorities will thus determine whether these fears are justified or not.

Conclusions

The new dose constraint that the ICRP is proposing seems to be consistent with the Publication 60 approach (as an upper bound to optimisation), but seems to be applied to a much broader spectrum of situations (all exposures situations as opposed to only controlled practices). This would be a welcome simplification and thus an advantage in terms of applicability and ease of presentation. However, depending upon how the new approach is interpreted and applied by regulatory authorities, it will cause more or less change "on the shop floor". As discussions move from "ICRP philosophy" to "the application of ICRP recommendations", the topic of dose constraints will most likely continue to occupy a central position in the debates. ■

Note

1. ICRP Publication 60 of 1990 contains the recommendations upon which most national radiological protection regulations are currently based.

Nuclear energy in the hydrogen economy

E. Bertel, K.-S. Lee, C. Nordborg *

In the current fossil fuel economy, vehicles are fuelled mainly by petroleum products and a large share of power plants use fossil fuels. This seems difficult to sustain in the decades to come due to limited natural resources and harmful environmental impacts of fossil fuel burning at the local (e.g. urban smog), regional (e.g. acid rain) and global (climate change) levels.

The hydrogen economy is envisaged as an alternative path in which hydrogen would play a major role in energy systems and serve all sectors of the economy, substituting for fossil fuels. Hydrogen can be obtained from various primary energy sources that are domestically available in most countries, including nearly carbon-free sources such as renewable and nuclear energies. Consequently, the hydrogen economy would enhance security of energy supply and environmental quality. Hydrogen is an energy carrier that can be stored in large quantities, unlike electricity, and converted at the end-user point into electricity in fuel cells, with only heat and water as by-products. It is also compatible with combustion turbines and reciprocating engines (motors) to produce power with near-zero emission of pollutants.

Although current worldwide hydrogen production is no more than some 50 million tonnes per year, and a large portion of that production is not used for energy supply, its use as an energy carrier could become considerable, especially if fuel-cell vehicles would be deployed on a large commercial scale. For example, a fleet of 300 million fuel-cell cars in the world (the 2050 high scenario developed by the Committee on Alternatives and Strategies for Future Hydrogen Production and Use of the United States) would consume some 120 million tonnes of hydrogen annually.

Putting a hydrogen economy into place would require large-scale supporting infrastructure, representing major investments unlikely to be financed easily. Existing hydrogen production, transportation, storage and conversion technologies are still too costly for widespread use in energy systems, especially in the context of deregulated energy markets. Such challenges could raise doubts about the likelihood of a rapid emergence or even the viability of a hydrogen economy.

Nevertheless, the hydrogen economy is receiving higher visibility and stronger political support in several parts of the world. In his 2003 "State of the Union Address", the US President announced a $1.2 billion hydrogen initiative to reverse the growing dependence on foreign oil and to reduce greenhouse gas emissions. The Japanese Prime Minister and the President of the European Commission made official statements strongly supporting the emergence of a hydrogen economy.

There are many ongoing national programmes aiming at the development of a hydrogen economy such as the Hydrogen Initiative of the United States and fuel cell/hydrogen programmes in Japan and Korea. There are also various international efforts under way for the realisation of a hydrogen economy. Under the leadership of the

** Dr. Evelyne Bertel (evelyne.bertel@oecd.org) and Mr. Kwang-Seok Lee (kwang-seok.lee@oecd.org) work in the NEA Nuclear Development Division. Mr. Claes Nordborg (nordborg@nea.fr) works in the NEA Nuclear Science Section.*

Hydrogen production options

Raw feedstock	Processed feedstock	Production process	Energy source	Production strategy
Fossil fuels ● Coal ● Natural gas ● Oil	● Syngas ● Gasoline ● Diesel fuel ● Methanol ● Ammonia ● Direct use of raw stock	**Thermal** ● Reforming – Steam reforming – Partial oxidation ● Gasification ● Pyrolysis	**Thermal** ● Fossil ● Renewable ● Nuclear	**Distributed** ● Fuelling stations ● Individual buildings ● On-board
Biomass ● Lignocellulose ● Starch ● Vegetable oils ● Black liquor	● Ethanol ● Methanol ● Biodiesel ● Biogas ● Sugars ● Direct use of raw stock	**Electrochemical** ● Electrolysis ● Photoelectro-chemical **Biological** ● Photo-biological ● Aerobic fermentation ● Anaerobic fermentation	**Electricity** ● Fossil ● Renewable ● Nuclear **Photolytic** ● Solar	**Semi-distributed** ● Market-centered **Central** ● Resource-centered
Waste material ● Municipal solid waste ● Stack gases ● Waste water	● Direct use of raw stock			
Water	● Direct use of raw stock			

Source: DOE (2004), *Hydrogen Posture Plan: An Integrated Research, Development, and Demonstration Plan.*

United States, 15 countries and the European Commission launched the International Partnership for the Hydrogen Economy (IPHE) in 2003 to discuss common areas of interest in, and obstacles to, a hydrogen economy. Discussions have focused on research, development and demonstration projects; hydrogen policy and regulation; and the commercialisation of hydrogen-based energy technologies.

Hydrogen production technologies

The adequate supply of hydrogen is a prerequisite for the successful implementation of a hydrogen economy. Although hydrogen is abundant in the universe, it must be produced from compounds containing hydrogen, such as fossil fuels, biomass, or water, using thermal, electrolytic or photolytic energy. The table above shows some of the technological options that are or will be available for hydrogen production.

As shown in the table, nuclear energy is among the possible energy sources for hydrogen production since nuclear reactors can produce both the heat and electricity required for it. Furthermore, it is the most commercially mature, non-fossil-fuel energy source capable of producing hydrogen on a large industrial scale without significant CO_2 emissions.

Several technological options are possible for nuclear hydrogen production, including:

- electrolysis of water using electricity from nuclear reactors in off-peak periods;
- steam reforming of natural gas using high-temperature heat from nuclear reactors;
- high-temperature electrolysis of steam (HTES) using high-temperature heat and electricity from nuclear reactors;
- thermo-chemical water splitting using high-temperature heat and electricity from nuclear reactors.

Electrolysis of water is attractive when cheap electricity is available or high-purity hydrogen is required. The use of nuclear-generated electricity in off-peak periods would be economically attractive in light of the low marginal cost of nuclear power plants.

Currently hydrogen is produced mainly by steam reforming of natural gas/methane. This is a catalytic process involving the reaction of natural gas with steam to produce a mixture of hydrogen and CO_2, requiring temperatures in the range of 500 to 950°C. Nuclear-assisted steam reforming has great potential for large-scale hydrogen production in the near term. This well-established process, however, has CO_2 as a waste product.

Hydrogen can be obtained more efficiently by significantly raising the temperature of water. The electrolysis of steam at higher temperatures (800-1000°C) offers several advantages, including lower electricity requirements and higher efficiency resulting from lowering the activation barriers at the electrolyte surfaces.

Since direct thermolysis (separation by heat) of water requires temperatures over 2500°C, in practice the thermo-chemical water-splitting process is accomplished by successive partial reactions, each running at a lower temperature level (800-1000°C). Many potential thermo-chemical cycles have been tested and the most promising for efficiency and practical applicability to nuclear heat sources seem to be the iodine-sulphur (IS), bromine-calcium (Ca-Br) and copper-chlorine (Cu-Cl) cycles. In addition, a thermo-chemical hybrid process, which combines both thermo-chemical and electrolytic reactions of water splitting with the possibility of running low-temperature reactions, could be another option.

Nuclear reactors for hydrogen production

Other than electrolysis of water, nuclear hydrogen production processes require temperatures in the range of 500 to 1000°C. Current and near-term, water-cooled reactors produce temperatures under 350°C and are not adapted to those processes. Therefore, reactor designers are focusing their interest on reactors capable of providing higher outlet temperatures. National and international efforts are devoted to the development and deployment of nuclear reactors for hydrogen production, especially high-temperature, gas-cooled reactors (HTGR).

For example, in Japan, the Japan Atomic Energy Research Institute (JAERI) constructed the High-Temperature Engineering Test Reactor (HTTR) with a coolant outlet temperature of 950°C. JAERI has been conducting studies on the production of hydrogen by using the heat from the HTTR, initially in steam reforming of natural gas and later with the iodine-sulphur, thermo-chemical process.

In the United States, General Atomics proposes the gas turbine modular helium reactor (GT-MHR) concept, which operates with an outlet helium temperature in the range of 850-1000°C and can be coupled to the thermo-chemical hydrogen production process and high-temperature electrolysis of steam. Other gas-cooled reactor concepts under development, such as the pebble bed modular reactor (PBMR), have similar outlet temperatures and could be designed for hydrogen production.

The sodium-cooled fast reactor (SFR), developed at the demonstration level in several countries, although operating at lower temperatures than the HTGR, may also be used for hydrogen production with a thermo-chemical and electrolytic hybrid process, which would require temperatures of about 500-600°C.

The Generation IV International Forum (GIF), an international endeavour to develop new nuclear reactors for potential deployment before 2030, includes hydrogen and other non-electricity products among the major goals. In fact, all six reactor concepts selected by GIF could produce hydrogen and four can even be used for thermo-chemical hydrogen production: the very high temperature reactor (VHTR), the gas-cooled fast reactor (GFR), the molten salt reactor (MSR) and the lead-cooled fast reactor (LFR) with outlet temperatures of 1000°C, 850°C, 700-800°C and 550-800°C, respectively.

Challenges and opportunities

Nuclear energy has the potential to play a significant role in a hydrogen economy, but there are large uncertainties in the hydrogen demand growth rate and eventual demand level, as well as in the share of nuclear energy in total hydrogen supply. Many factors will influence the implementation rate and characteristics of a hydrogen economy, including new infrastructure development, maturity of relevant technologies, economic growth, changes in life patterns and social acceptance. The role of nuclear energy will depend on how the hydrogen economy will be shaped in the transition period as well as in its final stage.

According to how early and how deeply hydrogen penetrates as an energy carrier in various sectors of the economy, the requirements for the development of nuclear hydrogen production will be different. For example, if demand for distributed hydrogen production prevails rather than for centralised production, the development of small- and medium-size reactors would be relevant. The development of nuclear hydrogen production technologies, in turn, may affect the shaping of the hydrogen economy by providing timely and attractive options. In this connection, it is essential for the nuclear energy sector to be involved and participate actively in the discussions on the hydrogen economy.

In light of recent trends in energy markets, strong competition is expected between alternative options to supply hydrogen. As shown in the table, there are many technical options for hydrogen production and a large number of technologies, such as steam reforming of methane, steam coal gasification with sequestration of CO_2 and the solar photovoltaic process, are already available or under development. Nuclear hydrogen production technology should be ready for deployment and competitive in a deregulated market, although the short- or even medium-term demand for hydrogen-producing reactors is unlikely to be comparable to the yearly mass reactor orders that occurred in the 1960s and 70s.

Nuclear energy has two key advantages for hydrogen production: it is nearly carbon-free and, with reactors delivering high-temperature heat, it is extremely efficient, reducing the natural resource demand and enhancing economics. The development at the industrial and commercial level of innovative, high-temperature reactors under investigation at present will require large R&D programmes likely to need government support in an international co-operation framework.

The transition to a hydrogen economy is inevitably a long-lasting process that will take at least several decades, likely 30 years or more. The long-term prospects for alternative technology options for hydrogen generation will depend to a certain extent on early demonstration of feasibility and viability. For instance, nuclear-assisted steam methane reforming could be pursued as an early nuclear option, which will facilitate further market penetration of more innovative nuclear hydrogen production technologies.

The development of nuclear hydrogen production technologies requires a long-term commitment with many uncertainties for the future. All stakeholders in government bodies and the industry have a role to play in the eventual success of nuclear hydrogen production. Co-ordination and joint efforts will be necessary in organising R&D programmes, infrastructure building and policy making to address the challenges of developing competitive and efficient technical processes for nuclear hydrogen production.

The development of nuclear hydrogen production would increase not only the demand for new reactors, including new sites, additional manpower and capital investments, but also the requirements for nuclear fuel, including its main natural component, uranium. Recognising that natural uranium resources, although very large, are by definition finite, a significant deployment of nuclear hydrogen production would enhance the attractiveness of advanced fuel cycle options more efficient in the use of the energy content of natural resources, uranium and thorium.

The use of nuclear energy for hydrogen production is likely to face the same obstacles as electricity generation, or any other application. Addressing public concerns regarding nuclear safety, radioactive waste management and disposal, and weapons proliferation is a prerequisite when considering a broad deployment of nuclear energy to supply hydrogen, which might entail in the long term much more than doubling the number of reactors in operation worldwide. Depending on the design of the hydrogen production and distribution system to be implemented, some of those issues, e.g. safety and non-proliferation, may deserve specific attention.

In countries wishing to rely on nuclear energy in the long term, the role of governments for the emergence of nuclear hydrogen production is very important in terms of basic R&D, initial technology development and policy making to create a favourable business environment without interfering with market mechanisms.

International co-operation is essential to ensure the design and implementation of a hydrogen economy and the development of nuclear systems for producing hydrogen efficiently. In particular, the efforts required in the field of nuclear R&D, and infrastructure building, are likely to be beyond individual country capabilities. In this context, undertakings like GIF, for example, can enhance the synergy between national programmes and the effectiveness of overall efforts. ■

Shifting paradigms in managing radioactive waste

Y. Le Bars, C. Pescatore *

Radioactive waste management (RWM) issues are embedded in broader societal issues such as the environment, risk, energy policy and sustainability. In all of these fields there is an increasing demand for stakeholder involvement. Managers in both the public and private sectors find that such involvement can improve the quality and the sustainability of policy decisions, and participation is recognised today as one of the five "principles of good governance" together with openness, accountability, effectiveness and coherence.[1]

Stakeholder involvement in policy making has received considerable attention within the OECD.[2] Moreover, public information, consultation and/or participation in environmental or technological decision making are required by a number of international treaties. For RWM, these include the Joint Convention[3] and, in Europe, the Espoo and Aarhus Conventions.

The NEA Forum on Stakeholder Confidence[4] (FSC) was set up in 2000 as the result of a decade-long process during which stakeholder confidence issues increasingly took a more central stage in the formulation and implementation of long-term solutions for managing radioactive waste, and during which a cultural shift took place making "stakeholder dialogue" a lead principle in radioactive waste management. The FSC considers "stakeholder" to mean *any actor* – institution, group or individual – *with an interest or a role to play* in the societal decision-making processes associated with RWM.

A recent NEA publication entitled *Learning and Adapting to Societal Requirements for Radioactive Waste Management* brings together the key FSC findings and experience covering four years of work. Six main areas are targeted in the publication and are briefly described below.

Favourable conditions for issuing radioactive waste management policy

Technical expertise and technical confidence are insufficient, on their own, to justify waste management solutions to a wider audience, or to see them through to successful implementation. A successful waste management policy requires previous elaboration of national policy on energy choices in which the waste management programme is embedded as well as recognition – at the national level – that the status quo regarding waste management needs changing. Additionally, clarity is needed on the waste inventory and the final destination by waste type.

Since mechanisms, procedures and practices for managing radioactive waste are chosen to be compatible with the political system and decision-making culture of each country, there is no one-size-fits-all solution. However, as more and more players demand an active role, all national programmes will have to achieve a balance between the approaches of participative democracy (whereby the stakeholders contribute the specificities of their demands and interests in a project) and representative democracy (whereby the elected representatives, both local and national, contribute their vision and engagement).

The design of the decision-making process

In today's decision-making context a "decision" no longer means opting for, in one go and for all time, a complete package solution. Instead, a decision is one step in an over-

** Mr. Yves Le Bars (e-mail: yves.lebars@andra.fr) is Chairman of the Forum on Stakeholder Confidence (FSC) and President of Andra; Dr. Claudio Pescatore (e-mail: claudio.pescatore@oecd.org) is Principal Administrator for RWM at the NEA and Technical Secretary of the FSC.*

all, cautious process of examining and making choices that preserve the safety and well-being of the present generation and the coming ones while not needlessly depriving the latter of their right of choice. Consideration is thus increasingly being given to the better understanding of concepts such as "stepwise decision making" and "adaptive staging" in which the public, and especially the most affected local public, is meaningfully involved in the planning process.[5]

Decision processes are expected to meet a number of competing requirements, e.g. they need to be participatory and accountable, goal-centred and adaptable. Competing requirements should be balanced by combining various policy tools, formal and informal procedures, analytic and deliberative techniques, linear and reversible steps, and their balance should be compatible with the type and context of the decisions.

Three overarching principles are the essential elements of any decision making seeking broad societal support:

- *Decision making should be performed through iterative processes, providing the flexibility to adapt to contextual changes*, e.g. by implementing a stepwise approach that provides sufficient time for developing a competent and fair discourse. The latter will also benefit from exposing existing research and its independent assessment to wide consultation.
- *Social learning should be facilitated*, for example by promoting interactions between various stakeholders and experts.
- *Public involvement in decision-making processes should be facilitated*, for example by promoting constructive and high-quality communication between individuals with different knowledge, beliefs, interests, values and world-views.

The social and ethical dimension

Competing values inevitably need to be embodied in societal decision processes for these to be successful. The tension that exists between competing values such as technical efficiency, support by the stakeholders and distributive equity, lends complexity to decision-making processes. Additionally, for projects having a lifetime of decades, the dominant values approved by society may change over time.

There are multiple legitimate views and ethical principles concerning the fairness of a decision's outcome. If they clash, there is no encompassing theory that could help decide which of the competing views should be considered more important. Management strategies that meet multiple ethical principles simultaneously (for example, not placing undue burdens on future generations while preserving potential energy resources for future use) have a better chance of gaining broad societal support. Identifying such strategies may rely on fair processes in which stakeholders seek a compromise between divergent ethical principles. Research indicates that it is impossible to satisfy all the competing values through an idealised decision-making process. In a highly developed democratic society, however, all desired criteria should be accommodated at least to a degree.

Requirements for technical safety and societal control need to be reconciled in radioactive waste management. To accommodate these often competing requirements, many implementing organisations are focusing their efforts on developing a final repository concept that incorporates provisions for retrievability. New processes to forecast and monitor quality of life and social impacts are also being brought to the fore.

Trust in the actors

Trust is "*a relationship between individuals within an existing or emerging group. It takes place in situations where individuals depend on people they trust to achieve important projects entailing significant risks for them*".[6] Process components can be designed to limit the reliance on trust and to try to restore trust where the trust relationship has been damaged. These include: i) involving in the decisions those who are affected, so that they gain more control; and/or ii) dividing major decisions into relevant steps, providing feedback after each step and allowing the affected people to halt the procedure if they lose trust in the "trustees". FSC delegates recognise the importance of stakeholder involvement in building trust, but also the importance that institutions develop appropriate features in the areas of organisation, mission and behaviour.

Trust and fairness issues will play an important role throughout the decision-making process. Building and maintaining trust requires sustained commitment of substantial resources.

Stakeholder involvement

Stakeholder involvement is a key concept in modern approaches to governance. Not recognising its relevance will, most likely, lead one to failure.

OECD countries are moving away from a traditional "decide, announce and defend" model, for which the focus has been almost exclusively on technical content, to one of "engage, interact and co-operate", for which both technical content and quality of process are of comparable import to a constructive outcome. In this context, the technical side of waste management is no longer of unique importance; organisational ability to learn, to communicate and to adapt moves into the foreground.

Involvement rests on providing information and may include consultation, active participation and shared decision authority. Management tools[7] are available, as are mandated instruments (e.g. environmental impact assessments), which include stakeholder involvement. Stakeholder involvement improves the information base for decisions, and broad participation may also compensate to some degree for the unavoidable absence of future generations in today's reflections or negotiations.

Institutions must be able to accommodate these changes in order to carry out the long-term projects for which they are responsible. Institutions capable of achieving and maintaining stakeholder confidence will need focused efforts in the three main areas of organisational aspects, mission and behaviour.

The local dimension of radioactive waste management

Long-term radioactive waste management involves the construction of only a limited number of facilities and it is therefore a national problem with a strong local dimension. Typically, it is only once a facility is located, or investigations are carried out, at a specific site that the greatest attrition manifests itself between national imperatives and local desires. Moving from the national to the local dimension requires the pre-existence of a decision-making process that is widely supported, and adhered to, by all actors. The informing principles of this decision-making process should take into account that safety is the paramount criterion for the local acceptability of a facility and that participation in decision making and oversight, as well as the provision of community development schemes, are further contributors to trust in the process and the hosting of the facility.

Conclusions

The environment for decision making has been changing in a significant way in society, and large-scale technology projects are rejected, in general, when stakeholders have not been actively involved in creating them or developed a sense of responsibility for them. A trend can be seen in OECD countries towards implementing forms of participatory democracy that require new or enhanced dialogue amongst all concerned parties. Dialogue and stakeholder involvement have thus become a central part of the waste management process.

Best practice in RWM has shifted from the traditional "decide, announce and defend" model to one of "engage, interact and co-operate". Time spent in dialogue, and in bringing stakeholder input into the organisation and into the waste management programme, is now seen to be time well spent.

Practitioners acknowledge that their roles have evolved in response to a change in the definition of radioactive waste management. In particular, as dialogue and stakeholder involvement have become a central part of the waste management process, scientists are having to address new questions raised by the general public, implementers are engaging in early, pro-active dialogue and regulators are becoming involved in the waste management process far earlier than before. Indeed, regulators have come to see their role increasingly as "safety communicators" and "peoples' experts", and recognise that they need to be involved in that role from the start of consultations with local communities, before final decisions on facilities, sites and concepts are rendered.[8] Policy specialists are also exploring new forms of dialogue with a wider range of stakeholders. It has been broadly acknowledged that there needs to be clarity of roles as well as visibility for the institutional actors. ■

Notes

1. Good governance relies on "policies designed on the basis of reasonable decisions that are well communicated and discussed with the public". NEA (2002), *Society and Nuclear Energy: Towards a Better Understanding*, OECD, Paris. Online at www.nea.fr/html/ndd/reports/2002/nea3677.html.
2. See for instance OECD (2001), *Citizens as Partners: Information, Consultation and Public Participation in Policy-making*; OECD (2001), *Citizens as Partners: OECD Handbook on Information, Consultation and Public Participation in Policy-making*; OECD (2003), *Open Government: Fostering Dialogue with Civil Society*; or OECD (2004), *Problems and Promise of E-Democracy: Challenges of Online Citizen Engagement*, OECD, Paris.
3. *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*. Online at www-ns.iaea.org/conventions/waste-jointconvention.htm.
4. For more information on the FSC and its publications, see the FSC web page at www.nea.fr/html/rwm/fsc.html.
5. See the NEA report of 2004 entitled *Stepwise Approach to Decision Making for Long-term Radioactive Waste Management* (available at www.nea.fr).
6. European Commission (2000), "The TRUSTNET Framework: A New Perspective on Risk Governance", Project Report, No. FI4P-CT96-0063, EC, Brussels.
7. NEA (2004), *Stakeholder Involvement Techniques: A Short Guide and Annotated Bibliography*, OECD, Paris.
8. See NEA (2003), *The Regulator's Evolving Role and Image in Radioactive Waste Management*, OECD, Paris.

Safe nuclear power plants: technical support services and contractors

B. Kaufer *

A common concern to both regulators and the nuclear industry is the ongoing gradual loss of experienced and competent personnel in nuclear technology, and the resulting weakening of nuclear field organisations. In some cases nuclear power plant vendors have merged with other companies and are no longer offering their earlier designs, while the technical strength of some others has decreased since the time they were actively designing and constructing nuclear power plants (NPPs). Consequently, some nuclear operating organisations have difficulty finding sufficient external support needed for the maintenance and operation of their facilities. Additionally, suppliers of specific nuclear equipment are disappearing from the market and as a result the in-depth knowledge on the design features of their equipment is being lost. Similarly, nuclear research institutes and other expert organisations have reduced their nuclear staff and budget.

Several alternatives can be used to fill this gap. One is for the licensee(s) to either strengthen their overall technical support services or maintain expertise in vital areas. But market competition is leading licensees to reduce operating costs, which in turn can lead to safety challenges. Another alternative is to use consultants and specialised companies that offer contracted services. The drawback to this approach is that the expert knowledge of these contractors is often limited in scope, and does not include a comprehensive understanding of the NPP safety concept. Furthermore, contractors may not have had sufficient involvement and experience at the specific plant sites where they are working. Therefore they require due guidance and supervision by the operating organisation.

The licensee's ability to maintain control over the nuclear safety aspects of the technical support services and contracted work represents a safety concern that cuts across the spectrum of contracting activities. This ability was identified as a topic for which an international exchange of views and experience could bring useful insights to operators and regulators. It was considered worthwhile to identify commendable means used by the operators to maintain such control as well as the type of regulatory oversight (e.g. inspections, assessment, etc.) that allows the regulator to gain assurance of the adequacy of such controls. Recognising the importance of these concerns, the NEA Committee on Nuclear Regulatory Activities (CNRA) decided to hold an international forum on this subject in June 2004. Heads of nuclear regulatory authorities were brought together with executives from the nuclear industry to exchange perspectives and experience.

The underlying starting point for this forum was a survey performed by the CNRA Working Group on Inspection Practices (WGIP). The survey was undertaken by the WGIP to identify trends and impacts from the use of contractors by NPPs in member countries. The resulting report, NEA/CNRA/R(2003)4, was used as a basis for planning and holding discussions at the forum.

The report itself was based on a survey that consisted of 20 questions that focused on licensing, process control, safety issues and other inspection areas. Fourteen member countries completed the survey. The appendices to the report include the survey questionnaire, a summary table of the answers received and the full text of the answers. The results indicate that the NPP licensees in all

** Mr. Barry Kaufer (e-mail: barry.kaufer@oecd.org) works in the NEA Nuclear Safety Division.*

surveyed countries use contractors. The spectrum of contracted activities includes maintenance, inspections, engineering and analytical services. Management and operator tasks (e.g. control room operations) are not contracted out.

The main objectives of the June 2004 forum were to have an international exchange of views which would:

- focus on the means used to ensure the safe operation of NPPs – looking at how operators control the quality of contracted work; at technical support; and at regulatory oversight of the competence of both operator and contractor;
- provide a clear picture of the current use of expert support to nuclear power plant operation and identify commendable solutions for ensuring the availability of support, including in the future;
- improve understanding of what the regulators, licensees and contractors should do to promote resolution of the concern.

During the forum debates, three key areas of interest emerged: the overall environment, the licensees' responsibilities and the regulators' responsibilities. Small breakout sessions were held to further develop these themes; the discussions can be briefly summarised as follows:

The overall environment

- Globalisation and consolidation – While fewer key suppliers of nuclear components exist, many small expert contractors are available and sufficient competition continues. It is clear that the use of contractors will continue, but what is important is to clearly recognise how and what work they do.
- While the nuclear industry is considered to be a specialised environment, the use of contractors is not unique to this sector. The overall environment differs nevertheless throughout the world and undergoes change (e.g. market economies, political uncertainty, etc.).

The licensees' responsibilities

- The licensee is always responsible for safety. Core activities such as control and supervision of operation, or quality assurance, cannot be contracted out. In order to fulfil their responsibilities, they must be "smart buyers"/"intelligent customers". This requires good control, supervision and oversight of contractors' work.

The regulators' responsibilities

- The regulator needs to provide clear explanations of what is required to the highest management levels of the licensee or its parent organisation, and to closely follow the contractors' actions to ensure that safety.
- The regulator must have sufficient, appropriate tools (e.g. expertise, resources, etc.) and must maintain capability for self- or independent review.

After having reviewed the outcomes of the discussions, the forum's final open panel presented the following conclusions:

- Licensees need to develop strategies for dealing with diversified contractors who are becoming more global.
- Regulators need to develop their practices for verifying adequate arrangements between licensees and contractors.
- Licensees need to improve their own knowledge in order to conduct more technical work in-house or to become more intelligent customers.
- Certain core tasks cannot be outsourced and must be conducted by the licensee staff (international guidance is needed on what those tasks are).
- Contracting work is not a threat to safety but management of the tasks on site must be in the hands of the licensee.
- There is a need to develop a concrete description of what is meant by the statement "the licensee has full responsibility for the safety of the plant"; international guidance on this is missing today.

It was noted that the latter point on defining what licensee responsibility means has been debated for some time and may be an appropriate topic for further discussion by NEA committees. The NEA Committee on the Safety of Nuclear Installations will be assessing and determining how to address this issue in its forthcoming programme of work. ■

Ensuring safety by being clear about responsibilities

One of the keys to ensuring safety at nuclear power plants, as well as many other industrial facilities, is to be clear about who is responsible for what. Failure to do so can lead to tasks undone or poorly done, producing in certain cases the opposite of the intended outcome. This point was summed up by Nils Diaz, Chairman of the US Nuclear Regulatory Commission, during his presentation at the forum. He told the story about four people named Someone, Anyone, Everyone and No one. There was an important job that had to be done; Someone should have done it; Anyone could have done it; Everyone thought that Someone would do it. In the end, No one did it. At the beginning, the responsibility was not assigned.

Safe, efficient and cost-effective decommissioning

C. Pescatore, T. Eng *

On 6-10 September 2004, an international NEA workshop was held in Rome on "Safe, Efficient and Cost-effective Decommissioning". The workshop was held under the high patronage of Carlo Azeglio Ciampi, the President of Italy, and was organised by several NEA standing technical committees[1] in co-operation with the International Atomic Energy Agency (IAEA) and the European Commission (EC). APAT, the Italian agency for environmental protection and technical services, and SOGIN, the Italian agency in charge of decommissioning, hosted the event.

The workshop was a follow-on to the Rome workshop of May 1999 on regulatory aspects of decommissioning. The scope was broader, however, in order to enable experts to determine progress in decommissioning since then and to formulate proposals for future international co-operation in this field.

The workshop was attended by over 200 participants from 22 countries. Participants included technical and policy experts, regulators, experts in stakeholder involvement issues, and officials from the Italian Government, the IAEA, the EC and the NEA.

The chairman of the workshop was Margaret Federline, Deputy Director of the Office of Nuclear Material Safety and Safeguards at the US Nuclear Regulatory Commission (NRC). The meeting format involved presentations from key experts followed by extensive discussion facilitated by expert panels. In all areas covered during the workshop, future challenges were identified as well as suggested solutions. The workshop included the following main sessions: international stocktaking; the Italian decommissioning context; disposal and materials management; techniques; management of transition and change throughout decommissioning; funding and costs; regulation and safety.

Participants were also able to visit the decommissioning project at the Latina nuclear power plant near Rome.

Key messages

International stocktaking

The session on international stocktaking sought to develop a vision of what should be done next on integrating international activities on decommissioning. After having observed that safe decommissioning can and has been done[2], participants also noted that related experience is increasing, and is being gathered, assessed and incorporated into guidance for future activities.

At the international level, the NEA, the IAEA and the EC should complement each other and ensure that their efforts are effectively co-ordinated. Participants generally felt that the IAEA should focus on basic safety principles and publish standards most helpful to developing nuclear programmes, while the NEA should continue to share and gather information from well-developed programmes, and identify and disseminate best practices for decision makers at all levels. All three organisations should have responsibility for updating the current NEA "map" of international activities on decommissioning. Participants also considered that outreach should be strengthened and extended to organisations involved in "conventional" waste management (i.e. toxic wastes).

The Italian decommissioning context

The session on the Italian decommissioning context included speeches from the Italian Ministry of Industry, the Ministry of Environment, APAT, SOGIN, the *Istituto Superiore di Sanità* (ISS), *the Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro* (ISPESL), Ansaldo and Cirten. Together with the study visit to the Latina nuclear power plant, where decommissioning work is ongoing, this session gave all workshop participants a thorough overview of the current situation regarding decommissioning in Italy and the challenges that lie ahead.

Disposal and materials management

Here the target outcome of the session was: "To identify workable solutions to address

** Dr. Claudio Pescatore (claudio.pescatore@oecd.org) is Principal Administrator for radioactive waste management at the NEA; Mr. Torsten Eng (torsten.eng@oecd.org) also works in the NEA Radioactive Waste Management Division.*

the decommissioning waste disposal issue in a cost-effective way; and to identify and discuss implications on working to different clearance levels and ways forward." Some of the key messages from this session were:

- Member countries need to develop integrated, national decommissioning and waste management strategies.
- Unavailability of disposal facilities is not a sufficient argument against early dismantling, since only about 1-3% of the materials generated actually require disposal as radioactive waste.
- Early dismantling will generally result in lower overall costs, early reduction of residual risk and beneficial use from the collective knowledge of the existing workforce.
- Early inventories of types and quantities of materials and wastes are essential. An international project on waste estimation tools would be of great value.

Participants discussed whether the very large amounts of very low level radioactive materials should be subject to clearance and thereby costly measurements and/or decontamination. They noted that there are different rules and practices regarding clearance levels in different countries, and recommended further information exchange in this area. Participants also considered that having clearly defined national levels for application to decommissioning projects is more important than international harmonisation of the values.

The IAEA Guide on Exclusion, Exemption, and Clearance was recently published. Participants agreed that member countries should review the applicability of the guide to their national regulatory regimes and that the NEA Working Party on Decommissioning and Dismantling (WPDD) should take stock of the matter at its 2005 meeting to make recommendations on next steps and future NEA activities regarding clearance issues. Participants also felt that there is little point in further theoretical studies of clearance levels. The issues requiring attention now are public relations and political attitudes.

Techniques

Participants in this session looked to identify actions needed to improve existing national and international catalogues of decommissioning techniques and to explore points of interest for R&D. They found that current efforts of the NEA Co-operative Programme on Decommissioning (CPD), by way of databases and catalogues, are very much appreciated. However, more detailed information on various techniques and the situations and conditions where they are applied, would be very valuable.

Participants also found that even though decommissioning is now a mature commercial industry, it is important to continue with R&D designed to improve existing techniques and also to develop new techniques. Collaborative, international funding may be required. In addition, shared responsibility between site owners and contractors might be needed to employ new innovative techniques.

Finally, there seems to be a shift from developing completely new techniques to efforts on reducing cost and optimising existing techniques. R&D today also emphasizes remote decommissioning work and techniques to reduce secondary wastes. Future developments will also include use of mock-ups and 3-D computer simulation tools.

Management of transition and change throughout decommissioning

The objective of this session was to identify management issues in the transition phase and to present solutions that have worked. It also sought to identify future needs regarding a) management planning for, and transition to, decommissioning; b) management of decommissioning; and c) stakeholder engagement. The outcome of this session can be summarised in the following key points and messages:

- The need for early planning was re-emphasized. The principle is in fact widely accepted and built into facility design and licensing arrangements in many countries.
- Identifying and agreeing on the endpoint of decommissioning is a critical early step which affects the extent of clearance required, overall costs and the eventual impact on the local community.
- Decommissioning needs to be managed as a professional project in its own right.
- The question of whether to use a few major contractors or a larger number of small local contractors seemed to be of common interest and worth further study in the international context.
- Decommissioning regulation is not a simple extension of the operation regulatory regime.
- The regulatory burden should decrease as the risks with the facility decrease.
- Decommissioning requires culture change on behalf of both the operator and the regulator.
- Stakeholder involvement is key to progress. Positive examples were cited where local communities were involved and even led the development of strategies and management plans.

Funding and costs

The existing systems for securing decommissioning funds range from having no specific provision at all to having a secure, segregated fund in independent, trustworthy hands. Participants generally agreed that the latter is the most favourable solution.

Waste management can constitute up to 60% of decommissioning costs, and the transportation of waste can be as high as 25%. Cost reductions might be possible if regulators and the public can accept the transport of large components (pressure vessels, steam generators, etc), rather than adopting the more labor-intensive and expensive approach of cutting these components into smaller, more easily transportable pieces. The reliability of cost estimates today depends on whether one thinks that ±15% is reliable or not.

Improved reliability of cost estimations needs good, prior characterisation of the plant in question. Poor accuracy can result from changing the scope of work during or after cost-estimation; not giving proper attention to inflation, the discount rate, or the year of cost accounting; and having to factor in allowances for contingencies and risk without a clear and agreed methodology. Independent reviews of costs as a project progresses can help minimise the uncertainties about costs.

The NEA, the IAEA and the EC have proposed a joint standardised form of accounting for consistency. Difficulties remain, however, because of commercially sensitive information. More discussions on this seem warranted. Participants also felt that international work on developing cost-estimating methodology should be re-established. However, since the costs of decommissioning and waste management constitute only 3-5% of the cost of nuclear energy production, it might be difficult to obtain the necessary interest and co-operation.

Regulation and safety

The target outcome of the session was to review international trends in regulation, including identifying challenges for implementation as regards transition to decommissioning, licence termination and the safety case. The main outcomes of the session were:

- The transition phase is expected to be a time of enhanced regulatory activity and scrutiny of the operator's work.
- During the transition phase a cultural change is needed both within the licensee's and the regulator's organisations.
- The nuclear regulatory burden should decrease as the relevant risks and hazards are reduced during decommissioning.
- The regulatory requirements for the safety case have to be flexible as the plant configuration is continuously changing.
- US participants described a risk-informed regulatory approach to achieve improvement of the focus on safety, effectiveness, efficiency and realism in regulatory decisions, and to reduce unnecessary regulatory burden, and cost, on licensees.
- Participants from France described a new integrated approach framework implemented in 2003, with a decommissioning licence authorising the complete project and placing more weight on the responsibility of the licensee.
- Transparent dialogue with local stakeholders needs to take place as part of the environmental impact assessment (EIA). It was suggested in particular that the end-state should not be standardised in regulations but be heavily influenced by the local stakeholders.
- A potential subject for future international work is: What can be done to reduce nuclear regulatory burdens as risks and hazards are reduced or as they change from being nuclear-related to conventional industrial risks and hazards?
- International harmonisation of safety requirements, such as clearance levels, must be based on the IAEA Safety Standards and the "Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management".

Overall conclusions

Overall the workshop concluded that significant progress has been made since the last meeting in Rome in 1999. Decommissioning is now a mature industrial process and the siting of waste disposal facilities is under way in many countries. Techniques for performing decommissioning have also matured and most of the R&D is now focused on optimising available techniques even if new, innovative techniques are also being developed. We are on our way to achieving realistic regulatory frameworks that take into account the fact that risks and hazards are reduced during decommissioning. Strong community and stakeholder involvement mechanisms are being used in many countries. Funding mechanisms are in place or being implemented in many countries.

The challenges ahead include work to produce realistic standards, to sustain nuclear skills even when the facilities are no longer in operation, and to validate cost estimates to obtain good background information for decision making. Perhaps the most challenging task is to overcome government and public sensitivity of the nuclear issue, and to obtain public acceptance for decommissioning end-points and procedures. ■

Notes

1. The Radioactive Waste Management Committee (RWMC), the Committee on Nuclear Regulatory Activities (CNRA), the Committee on the Safety of Nuclear Installations (CSNI), the Committee on Radiation Protection and Public Health (CRPPH) and the Nuclear Development Committee (NDC).
2. See also NEA (2004), *Decommissioning of Nuclear Power Facilities – It can and has been done*, OECD/NEA, Paris.

NEA joint projects

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

Project	Participants
Cabri Water Loop Project Contact: carlo.vitanza@oecd.org Current mandate: 2000-2008	Czech Republic, Finland, France, Germany, Hungary, Korea, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States
Co-operative Programme on Decommissioning (CPD) Contact: torsten.eng@oecd.org Current mandate: January 2004-January 2009	Belgium, Canada, Chinese Taipei, France, Germany, Italy, Japan, Korea, Slovak Republic, Spain, Sweden, United Kingdom
Fire Incidents Records Exchange (FIRE) Project Contact: eric.mathet@oecd.org Current mandate: January 2003-January 2006	Czech Republic, Finland, France, Germany, Japan, Spain, Sweden, Switzerland, United States
Halden Reactor Project Contacts: pekka.pyy@oecd.org carlo.vitanza@oecd.org Halden contact: Fridtjov.owre@hrp.no Current mandate: January 2003-December 2005	Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Japan, Korea, Norway, Russia, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States
Information System on Occupational Exposure (ISOE Programme) Contact: lazo@nea.fr Current mandate: 2002-2007	Armenia, Belgium, Brazil, Bulgaria, Canada, China, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Korea, Lithuania, Mexico, Netherlands, Pakistan, Romania, Russia, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Ukraine, United Kingdom, United States
International Common-cause Data Exchange (ICDE) Project Contact: pekka.pyy@oecd.org Current mandate: April 2002-March 2005	Canada, Finland, France, Germany, Japan, Korea, Spain, Sweden, Switzerland, United Kingdom, United States

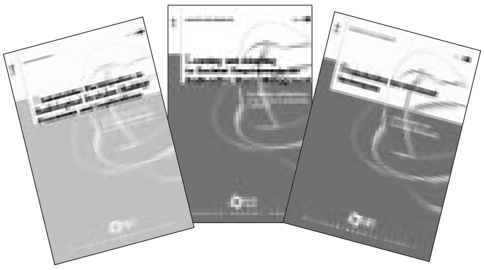
radioactive waste management, are one of the NEA's major strengths. All NEA joint projects currently under way are listed below.

Budget	Objectives
≈US$ 77.5 million	• 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).
≈€ 40 000 /year	• Exchange scientific and technical information amongst decommissioning projects on nuclear facilities.
≈€ 100 000 /year	• Define format and collect fire event experience (by international exchange) in a quality-assured and consistent database. • Collect and analyse fire events data over the long-term aiming 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 event attributes to enable quantification of fire frequencies and risk analysis.
≈US$ 45 million /year	Generate key information for safety and licensing assessments and aim at providing: • extended fuel utilisation: basic data on how the fuel performs, both at normal operation and transient conditions, with emphasis on extended fuel utilisation in commercial reactors; • degradation of core materials: knowledge of plant materials behaviour under the combined deteriorating effects of water chemistry and nuclear environment, also relevant for plant life-time assessments; • man-machine systems: advances in computerised surveillance systems, human factors and man-machine interaction in support of upgraded control rooms. These activities are collectively known as "The Joint Programme".
US$ 400 000	• 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, as a contribution to the optimisation of radiation protection.
≈US$ 45 million	• 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. • Record event attributes to facilitate the quantification of CCF frequency.

Project	Participants
MASCA-2 (Material Scaling) Project Contact: eric.mathet@oecd.org Current mandate: June 2003-June 2006	Belgium, Canada, Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, Russia, Slovak Republic, Spain, Sweden, Switzerland, United States
Melt Coolability and Concrete Interaction (MCCI) Project Contact: carlo.vitanza@oecd.org Current mandate: January 2002-December 2005	Belgium, Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, Norway, Spain, Sweden, Switzerland, United States
Piping Failure Data Exchange (OPDE) Project Contact: eric.mathet@oecd.org Current mandate: June 2002-June 2005	Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Korea, Spain, Sweden, Switzerland, United States
PKL-2 Project Contact: carlo.vitanza@oecd.org Current mandate: January 2004-December 2006	Belgium, Czech Republic, Finland, France, Germany, Hungary, Japan, Korea, Spain, Sweden, Switzerland, United Kingdom, United States
PSB-VVER Project Contact: carlo.vitanza@oecd.org Current mandate: February 2003-December 2006	Czech Republic, Finland, France, Germany, Italy, Russia, United States
SETH (SESAR Thermal-hydraulics) Project Contact: carlo.vitanza@oecd.org Current mandate: April 2001-June 2005	Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Japan, Korea, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States
Sorption II Project Contact: sylvie.voinis@oecd.org Current mandate: 2000-2004	Australia, Belgium, Czech Republic, Finland, France, Germany, Japan, Spain, Switzerland, United Kingdom, United States
Thermochemical Database (TDB) Project Contact: federico.mompean@oecd.org Current mandate: February 2003-February 2007	Belgium, Canada, Czech Republic, Finland, France, Germany, Japan, Spain, Sweden, Switzerland, United Kingdom, United States

Budget	Objectives
≈US$ 3 million	• Provide experimental information on the phase equilibrium for different corium mixture compositions that can occur in water reactors. • Generate data on relevant physical properties of mixtures and alloys that are important for the development of qualified mechanistic models.
≈US$ 4.8 million	• 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.
≈US$ 100 000 /year	• 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.
US$ 3.6 million	• Investigate pressurised water reactor (PWR) safety issues by means of thermal-hydraulic experiments to be conducted at the Primärkreislauf-Versuchsanlage (primary coolant loop test facility) in Germany. • One category of tests focuses on boron-dilution issues. • A second type of test addresses potential accident conditions during shutdown (mid-loop operation).
US$ 1.25 million	• Provide the unique experimental data needed for the validation of thermal-hydraulic codes and to support refinements to safety assessment tools for VVER-1000 reactors.
US$ 4.7 million	• Carry out thermal-hydraulic experiments in support of accident management at facilities identified by the NEA Committee on the Safety of Nuclear Installations (CSNI), such as those requiring international collaboration to sponsor their continued operation. • The first part of the programme addressing primary loop accidents has been completed. • The second part addressing data for computerised fluid dynamics (CFD) code validation for containment applications is under way.
≈€ 384 000	• To evaluate the capabilities of chemical thermodynamic models for describing radionuclide sorption phenomena over a range of geochemical conditions in order to increase confidence in the long-term safety analysis of radioactive waste repositories.
≈€ 1.6 million	Produce a database that: • contains data for all the 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.

New publications



General interest

The Strategic Plan of the Nuclear Energy Agency - 2005-2009

ISBN: 92-64-02081-0 *Free: paper or web.*

The new NEA Strategic Plan for 2005-2009 has recently been adopted. It offers a clear roadmap for achieving the goals that have been set by the NEA member countries, in particular in the areas of nuclear safety, radioactive waste management, radiological protection, nuclear science and technology development, and legal affairs. The Plan specifically outlines priorities, goals and objectives, and how these are to be accomplished. At the same time, it provides sufficient flexibility to respond to both new and evolving priorities as they arise.

Economic and technical aspects of the nuclear fuel cycle

Nuclear Competence Building

ISBN 92-64-10850-5 – Price: € 24, US$ 29, £ 17, ¥ 3 100.

In many countries, government R&D funding in the area of nuclear energy has been dramatically reduced or has disappeared altogether. At the same time, the profit margins of electricity generators have been severely squeezed. The combined effect has led to a reduction in technical innovation and the danger of the loss of technical competencies and skills in the area. However, because different countries are at different stages of the nuclear technology life cycle, these losses are not common to all countries, either in their nature or their extent. A competence that may have declined or been lost in one country may be strong in another. Therein lies one solution to the problems the sector faces: international collaboration. This report presents the results of an international survey on initiatives launched during recent years in the area of nuclear education and training. Key human resource issues are discussed and many good practices regarding international collaboration are identified. The report includes an executive summary along with conclusions and recommendations aimed at policy makers and other stakeholders. It also contains an in-depth analysis of the factual information collected.

Nuclear Competence Building

Summary Report

ISBN 92-64-02073-X *Free: paper or web.*

This booklet, a summary of the full report, presents the main results of an international survey on initiatives launched during recent years in the area of nuclear education and training. Key human resource issues are discussed and good practices regarding international collaboration are identified.

Nuclear regulation and safety

CSNI Technical Opinion Papers

No. 6: PSA-based Event Analysis

ISBN 92-64-02091-8 – Free: paper or web.

This technical opinion paper provides the reader with a concise description of both the benefits and disadvantages of using probabilistic safety assessment (PSA) to analyse operational events in nuclear power plants in order to facilite better operator feedback. The paper's objective is to present decision makers in the nuclear field with a clear technical opinion on how PSA techniques can be used to address this issue. The intended audience is primarily nuclear safety regulators, senior researchers and industry leaders. Government authorities, nuclear power plant operators and the general public may also be interested.

Debris Impact on Emergency Coolant Recirculation

Workshop Proceedings, Albuquerque, NM, USA, 25-27 February 2004

ISBN: 92-64-00666-4
Price: € 90, US$ 113, £ 62, ¥ 11500.

Under normal operation, nuclear reactor fuel is cooled by water circulating in the primary circuit. In the case of a loss-of-coolant accident, the reactor is stopped automatically. Residual fuel heat must then be evacuated, typically by use of a safety injection system and a reactor containment spray system. These systems are fed with water recovered from the bottom of the containment through sumps. However, because this water may contain debris (insulating material, concrete particles, paint), sumps are equipped with strainers. These strainers may become clogged, preventing emergency coolant recirculation. This could in turn lead to reactor core overheating, or melting in the most extreme circumstances. Participants at the workshop discussed the most recent research and developments in this field, as well as proposed and implemented solutions. These proceedings contain the papers presented at the workshop as well as a summary of the discussions that took place.

Regulatory Challenges Related to Human Performance

ISBN: 92-64-02089-6 Free: paper or web.

In June 2003, the OECD Nuclear Energy Agency (NEA) Committee on Nuclear Regulatory Activities (CNRA) organised a topical session on the importance of human performance to nuclear safety and the factors influencing it. The discussion focused on three questions: Is human performance as important to the safety of nuclear installations as many references seem to indicate? Has the importance of human performance increased during the past five to ten years? What recommendations can be made on how to manage human performance challenges? This publication provides a summary of the introductory presentations as well as a description of the regulatory challenges identified during the discussions. The publication's intended audience is primarily nuclear regulators; it may also be of interest to technical support organisations, nuclear operators, governmental bodies and the general public.

Radiological protection

Stakeholder Participation in Radiological Decision Making: Processes and Implications

Third Villigen Workshop, Villigen, Switzerland, 21-23 October 2003

ISBN: 92-64-10825-4 – Price: € 24, US$ 30, £ 17, ¥ 3 000.

Since 1988, the OECD Nuclear Energy Agency has been organising a series of workshops to address the various aspects of stakeholder involvement in radiological protection decision making. These workshops have been instrumental in forging consensus and improving understanding of key issues in this area. Building on the experience of the first two "Villigen workshops", the third in the series extensively analysed three case studies, which covered the licensing of a new facility, the clean-up and release of an old facility, and the rehabilitation of a large, contaminated area. Consideration was given to the stakeholder involvement processes that had been used, and the implications that these did or could have on radiological protection policy, regulation and application. The workshop papers analysing these processes and implications are presented in these proceedings, which should provide valuable examples and lessons for governments, regulators and practitioners.

Stakeholder Participation in Radiological Decision Making: Processes and Implications

Summary Report of the 3rd Villigen (Switzerland) Workshop, October 2003

ISBN: 92-64-02079-9 *Free: paper or web.*

This summary seeks to answer the questions that radiological protection professionals ask when confronted with the need to consider stakeholder participation processes. As will become clear, there is no one-size-fits-all blueprint for such processes: the sheer range and diversity of the situations where they may be appropriate dictates a much more flexible approach. However, the workshop demonstrated that it is possible to identify common themes and features. These should aid professionals in developing participation processes without detracting from the flexibility needed to remain responsive to the particular demands and expectations of any given situation. The report is intended for policy makers and regulators with radiological protection responsibilities.

Stakeholder Participation in Radiological Decision Making: Processes and Implications

Case Studies for the Third Villigen Workshop, Villigen, Switzerland 21-23 October 2003

ISBN: 92-64-02065-9 *Free: paper or web.*

Within the radiological protection community, stakeholder issues have moved steadily to the forefront of policy discussions, and clearly form a key element in decisions regarding the development and implementation of radiological protection policy. It was in this light that the OECD Nuclear Energy Agency (NEA) undertook three case studies on stakeholder involvement processes and experiences. Experience and lessons were analysed and extracted that may have application to numerous situations in other national contexts. They are intended to aid decision makers and regulators who are involved in radiological protection, and may have particular value for post-accident contamination situations, the siting of new nuclear installations, the management of emissions from routine operations at nuclear facilities, and the decommissioning of existing nuclear installations. The three case studies presented in this report were specifically developed as input to the workshop and address the following situations: the Canadian review process for uranium production projects in Northern Saskatchewan; the Rocky Flats controversy on radionuclide action levels; and the ETHOS project for post-accident rehabilitation in the area of Belarus contaminated by the Chernobyl disaster.

Radioactive waste management

Decommissioning of Nuclear Power Facilities –

It can and has been done

This brochure is also available in Italian as:

Decommissioning degli Impianti Nucleari –

Si può fare ed è stato fatto

Free: paper or web.

One concern commonly expressed about electricity production from nuclear power is that the decommissioning (i.e. dismantling to a desirable end state) of the redundant radioactive facilities presents a significant problem. In fact, international experience shows that this is not the case. This brochure looks at decommissioning across the spectrum of nuclear power facilities and shows worldwide examples of successful projects.

Engineered Barrier Systems (EBS): Design Requirements and Constraints

Workshop Proceedings,Turku, Finland, 26-29 August 2003

ISBN: 92-64-02068-3 *Free: paper or web.*

A joint NEA-EC workshop entitled “Engineered Barrier Systems: Design Requirements and Constraints” was organised in Turku, Finland on

26-29 August 2003 and hosted by Posiva Oy. The main objectives of the workshop were to promote interaction and collaboration among experts responsible for enginering design and safety assessment in order to develop a greater understanding of how to achieve the integration needed for the successful design of engineered barrier systems, and to clarify the role that an EBS can play in the overall safety case for a repository. These proceedings present the outcomes of this workshop.

Geological Disposal: Building Confidence Using Multiple Lines of Evidence

First AMIGO Workshop Proceedings, Yverdon-les-Bains, Switzerland, 3-5 June 2003

ISBN: 92-64-01592-2 – Price: € 50, US$ 63, £ 35, ¥ 6 400.

When preparing the safety case for a deep geological repository of radioactive waste, the integration of wide-ranging information from multidisciplinary sources is a complex task. This has provided the motivation for establishing AMIGO, an OECD/NEA international project on "Approaches and Methods for Integrating Geological Information in the Safety Case". AMIGO is structured as a series of biannual topical workshops involving site characterisation and safety assessment practitioners with experience in both sedimentary and crystalline rock settings. The first AMIGO workshop was organised in Yverdon-les-Bains, Switzerland on 3-5 June 2003. The main objective of the workshop was to exchange views on building confidence in analyses and arguments that support the safety case using multiple lines of evidence and integrating the work of geoscientists and safety assessors. These proceedings present the outcomes of the workshop.

Learning and Adapting to Societal Requirements for Radioactive Waste Management

Key Findings and Experience of the Forum on Stakeholder Confidence

ISBN: 92-64-02080-2 *Free: paper or web.*

This report presents a synthesis of the key findings and experience of the NEA Forum on Stakeholder Confidence regarding the governance of long-term radioactive waste management. Most of the main findings are of relevance to all public policy-making processes, not only to radioactive waste management. In this sense, the report reads as a primer on the concrete governance challenges facing complex, collective decision making.

Post-closure Safety Case for Geological Repositories

Nature and Purpose

ISBN: 92-64-02075-6 *Free: paper or web.*

Disposal of long-lived radioactive waste in engineered facilities deep underground is being widely investigated worldwide in order to protect humans and the environment both now and in the future. This report defines and analyses the purpose and general contents of the post-closure safety cases for such facilities. The aim is to provide a point of reference for people involved in the development of safety cases and those with responsibility for, or interest in, decision making in radioactive waste management.

Stakeholder Involvement Techniques

A Short Guide and Annotated Bibliography

ISBN: 92-64-02087-X *Free: paper or web.*

Stakeholder involvement, dialogue and deliberation can improve the quality and the sustainability of policy decisions. This publication offers a short guide to stakeholder involvement techniques and their selection. It includes an annotated bibliography pointing to easily accessible handbooks and other resources. While it approaches the topic from the point of view of radioactive waste management, it is intended for any person or organisation considering stakeholder involvement in decision making.

Stepwise Approach to Decison Making for Long-term Radioactive Waste Management

Experience, Issues and Guiding Principles

ISBN: 92-64-02077-2 *Free: paper or web.*

The decision-making process for developing and implementing long-term radioactive waste management (RWM) solutions extends over decades and involves both a multitude of actors/stakeholders and stages. In order to be sustainable and successful, a great deal of built-in flexibility is needed in designing and carrying out such processes. Concepts such as "stepwise decision making" and "adaptive staging" hold out a means by which the public, and especially the local public, can be meaningfully involved in the review and planning of radioactive waste management solutions. This review of stepwise decision making for long-term RWM pinpoints its current status, highlights its societal dimension and identifies implementation issues from both the point of view of social research and RWM practitioners. There is convergence between these two perspectives, and general guiding principles and action goals are proposed as a basis for further discussion and development of the stepwise decision-making concept.

Strategy Selection for the Decommissioning of Nuclear Facilities

Seminar Proceedings, Tarragona, Spain, 1-4 September 2003

ISBN: 92-64-01671-6 – Price: € 60, US$ 75, £ 42, ¥ 7 700.

As modern nuclear power programmes mature and large, commercial nuclear power plants and fuel cycle facilities approach the end of their useful life by reason of age, economics or change of policy on the use of nuclear power, new challenges associated with decommissioning and dismantling come to the fore. Politicians and the public may expect there to be a "right answer" to the choice of strategy for a particular type of facility, or even all facilities. Both this seminar and wider experience show that this is not the case. Local factors and national political positions have a significant input and often result in widely differing strategy approaches to broadly similar decommissioning projects. All facility owners represented at the seminar were able to demonstrate a rational process for strategy selection and compelling arguments for the choices made. In addition to the papers that were presented, these proceedings include a summary of the discussions that took place.

Nuclear Law

Nuclear Law Bulletin No. 73

(June 2004)

Two issues and supplements per year. *ISSN 0304-341X*
2005 subscription: € 90, US$ 103, £ 58, ¥ 12 200.

The *Nuclear Law Bulletin* is published twice a year in both English and French. It covers legislative developments in almost 60 countries around the world as well as reporting on relevant jurisprudence and adminisrative decisions, bilateral and international agreements and regulatory activities of international organisations.

+ Supplement to No. 73:

Croatia – Act on Nuclear Safety (promulgated on 21 October 2003)

ISBN 92-64-01710-0 – Price: € 21, US$ 26, £ 15, ¥ 2 700.

Nuclear Legislation: Analytical Study - 2002 and 2003 Updates

Regulatory and Institutional Framework for Nuclear Activities

ISBN: 92-64-01814-X – Price: € 60, US$ 75, £ 42, ¥ 7 700.

This 2002-2003 update of the Analytical Study on Nuclear Legislation in OECD member countries consists of replacement chapters for Belgium, Canada, the Czech Republic, France, Germany, Ireland, Mexico, Poland, Portugal, Sweden, Switzerland and the United Kingdom. It is organised on the basis of a standardised format for all countries, thus facilitating the search for and comparison of information. This update is based on information which was made available to the NEA Secretariat by the end of 2003.

Nuclear science and the Data Bank

Basic Studies in the Field of High-temperature Engineering

Third Information Exchange Meeting, Ibaraki-ken, Japan, 11-12 September 2003

ISBN: 92-64-01601-5 – Price: € 65, US$ 81, £ 45, ¥ 8 300.

In response to growing interest in high-temperature, gas-cooled reactors (HTGRs) in many countries and the need for improved materials for nuclear applications in high-temperature environments, the NEA organised the Third Information

Exchange Meeting on Basic Studies in the Field of High-temperature Engineering. The proceedings of this meeting provide an overview of high-temperature research currently under way, including studies on the behaviour of irradiated graphite and improvements in material properties under high-temperature irradiation. These proceedings also contain recommendations for further international work in the areas of high-temperature engineering.

Benchmark on Beam Interruptions in an Accelerator-driven System

Final Report on Phase II Calculations

ISBN: 92-64-02072-1 *Free: paper or web.*

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

Computing Radiation Dosimetry - CRD 2002

Workshop Proceedings, Sacavém, Portugal, 22-23 June 2002

ISBN: 92-64-10823-8 – Price: € 65, US$ 81, £ 45, ¥ 8 300.

Establishing reliable computational methods and tools for radiation dosimetry is of great importance today because of the increased use of radiation in a number of areas of science, technology and medical applications. Fields concerned include radiation protection, radiation shielding, radiation diagnostics and therapy, radiobiology, biophysics and radiation detection. A series of lectures delivered by experts provides the content of these workshop proceedings. They are a valuable reference for those wishing to better understand the most advanced computational methods in radiation dosimetry.

JANIS - Version 2.1 (A Java-based Nuclear Data Display Program)

Available on request.

JANIS (Java-based nuclear information software) is a display program designed to facilitate the visualisation and manipulation of nuclear data. Its objective is to allow the user of nuclear data to access numerical values and graphical representations without prior knowledge of the storage format. It offers maximum flexibility for the comparison of different nuclear data sets.

JEFF 3.0 Nuclear Data Library (The)

ISBN: 92-64-01046-7 *Free: paper or web.*

Neutronics/Thermal-hydraulics Coupling in LWR Technology

Vol. 1: CRISSUE-S – WP1: Data Requirements and Databases Needed for Transient Simulations and Qualification

ISBN: 92-64-02083-7 *Free: paper or web.*

The interaction between system thermal-hydraulics and 3-D neutron kinetics is relevant for both the safety and the design and operation of existing nuclear reactors and reactor cores. Today, advanced coupled thermal-hydraulics/neutronics computer tools along with powerful computers can perform realistic best-estimate analyses of complex power plant transients. The results provide new insights into the conservatisms for the specification of relevant operational safety margins and can imply new optimisations of emergency operating procedures in existing plants. They also improve knowledge of the physical phenomena behind "old-fashioned" problems (critical issues) in light water reactor technology, and can specifically shed light on the interaction between thermal-hydraulics and neutronics that still can challenge the design and operation of nuclear power plants. This report is the first of a series of three. It is devoted to the assembly and the structure of the existing database related to this subject.

Neutronics/Thermal-hydraulics Coupling in LWR Technology

Vol. 2: CRISSUE-S – WP2: State-of-the-art Report

ISBN: 92-64-02084-5 *Free: paper or web.*

This second volume provides the state-of the art report on this subject.

Neutronics/Thermal-hydraulics Coupling in LWR Technology

Vol. 3: CRISSUE-S – WP3: Achievements and Recommendations Report

ISBN: 92-64-02085-3 *Free: paper or web.*

This third report summarises the results, selects the most important findings and indicates the industry position on the related subjects.

Pyrochemical Separations in Nuclear Applications

A Status Report

ISBN: 92-64-02071-3 *Free: paper or web.*

The treatment of spent nuclear fuel is presently performed by the industry using different aqueous chemical processes. Alternative dry processes, using pyrochemical methods, are beginning to receive greater attention due to their potential advantages for more compact reprocessing plant designs, as well as for reduced criticality and radiation dose risks. Effective transmutation of long-lived fission products and minor actinides will be based in future on multi-recycling of the fuel with very high burn-up and short cooling times, conditions for which pyrochemical methods offer various advantages over traditional aqueous processes. Closed nuclear fuel cycles, considered for the future generation of nuclear reactors, could also benefit from pyrochemical reprocessing methods. Studies of pyrochemical processes have so far been carried out at laboratory level. Much R&D work will still be required in order to upgrade these processes to the level of current industrial aqueous processing. This publication describes ongoing national programmes, collaborative international activities, present research needs and future applications for pyrochemical methods, used in the treatment of irradiated nuclear fuel. It will be of particular interest to nuclear scientists involved in the development of advanced fuel cyles.

Shielding Aspects of Accelerators, Targets and Irradiation Facilities - SATIF 6

Workshop Proceedings, Stanford, California, USA, 10-12 April 2002

ISBN: 92-64-01733-X – Price: € 95, US$ 119, £ 66, ¥ 12 200.

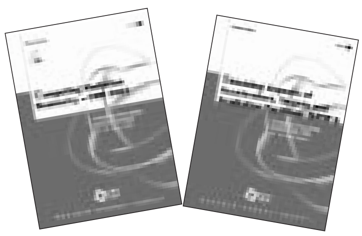
Particle accelerators are used today for an increasing range of scientific and technological applications. They are very powerful tools for investigating the origin and structure of matter, and for improving understanding of the interaction of radiation with materials, including the transmutation of nuclides and the beneficial or harmful effects of radiation. Particle accelerators are used to identify properties of molecules that can be used in pharmacy, for medical diagnosis and therapy, and for biophysics studies. Particle accelerators must be operated in safe ways that protect the operators, the population and the environment. New technological and research applications give rise to new issues in radiation shielding. These workshop proceedings review the state of the art in radiation shielding of accelerator facilities and irradiated targets. They also evaluate advancements and discuss the additional developments required to meet radiation protection needs.

The Need for Integral Critical Experiments with Low-moderated MOX Fuels

Workshop Proceedings, Paris, France 14-15 April 2004

ISBN: 92-64-02078-0 *Free: paper or web.*

The use of MOX fuel in commercial reactors is a means of burning plutonium originating from either surplus weapons or reprocessed irradiated uranium fuel. This requires the fabrication of MOX assemblies on an industrial scale. The OECD/NEA Expert Group on Experimental Needs for Criticality Safety has highlighted MOX fuel manufacturing as an area in which there is a specific need for additional experimental data for validation purposes. Indeed, integral experiments with low-moderated MOX fuel are either scarce or not sufficiently accurate to provide an appropriate degree of validation of nuclear data and computer codes. New and accurate experimental data would enable a better optimisation of the fabrication process by decreasing the uncertainties in the determination of multiplication factors of configurations such as the homogenisation of MOX powders. This report contains the proceedings of a workshop organised by the OECD/NEA Nuclear Science Committee. Issues debated include the expression of research needs, proposals of experimental programmes and prospects for an international co-operative programme to address these needs.



Where to buy NEA publications

North America:

Extenza-Turpin North America

56 Industrial Park Drive, Pembroke, MA 02359, USA
Tel.: +1 (781) 829 8973 – Fax: +1 (781) 829 9052
Toll free: +1 (800) 456 6323; E-mail: oecdna@extenza-turpin.com

Rest of the world:

Extenza-Turpin Distribution Services Limited

Stratton Business Park, Pegasus Drive,
Biggleswade, Bedfordshire, SG18 8TQ, UK
Tel.: +44 (0) 1767 604800; Fax: +44 (0) 1767 601640
E-mail: oecdrow@extenza-turpin.com; Website: www.extenza-turpin.com

Online ordering: www.oecd.org/bookshop

Browse OECD titles online at www.oecd.org/bookshop. Purchase the paperback and download the PDF e-book. Save 20% by buying just the PDF file. Consult our list of worldwide distributors.

Secure payment with credit card.

Where to order free NEA publications

OECD/NEA Publications Service

12, boulevard des Îles, F-92130 Issy-les-Moulineaux, France
Tel.: +33 (0) 1 45 24 10 15 – Fax: +33 (0) 1 45 24 11 10
E-mail: neapub@nea.fr – Internet: www.nea.fr

Online reports: www.nea.fr

Employment Opportunities

OECD Nuclear Energy Agency

Vacancies occur in the OECD Nuclear Energy Agency Secretariat in the following areas:

- Energy Economics
- Nuclear Safety
- Radioactive Waste Management
- Radiation Protection
- Nuclear Energy Economics
- Nuclear Science
- Nuclear Law
- Nuclear Engineering
- Computing

Qualifications:

Relevant university degree; at least two or three years' professional experience; very good knowledge of one of the two official languages of the Organisation (English or French) and ability to draft well in that language; good knowledge of the other.

Vacancies are open to candidates from OECD member countries. The OECD is an equal opportunity employer.

Initial appointment:

Two or three years.

Basic annual salary:

From € 55 285 (Administrator) and from € 79 275 (Principal Administrator), supplemented by allowances depending on residence and family situation.

For information regarding current vacancies see:

www.nea.fr/html/general/jobs/index.html

OECD PUBLICATIONS, 2 rue André-Pascal, 75775 PARIS CEDEX 16
PRINTED IN FRANCE
(68 2004 02 1 P) – ISSN 1605-9581