# Table of Contents

## Facts and Opinions

**Information of the Medical Profession on the Subject of Ionising Radiation**
M. Tabiani

**Partitioning and Transmutation of Actinides**

- Transmutation of Long-Lived Nuclear Waste
  K. Abrahams
- Statement by the NEA Radioactive Waste Management Committee on the Partitioning and Transmutation of Actinides

**Severe Accident Management: Prevention and Mitigation**
B.W. Sheron, and J. Royen

**Participation of the Public in Nuclear Energy Decisions: What Are the Conditions?**
R. Skjøldebrand

## Nea Update

**The Helsinki Symposium — Current Issues in Nuclear Third Party Liability**
P. Reynolds

**Nea Co-Operation with Central and Eastern Europe**
J. de la Ferté

**The Nea Co-Operative Programme on Decommissioning**
S. Menon

**Funding Schemes for Decommissioning Nuclear Power Plants**
G.H. Stevens

**Access to Software for Nuclear Technology**
N. Tubbs

**The Nuclear Power Situation in Oecd Countries**

## News Briefs

**New Publications from the Nea**

---

**Editorial board:** Jacques de la Ferté, Florence de Galnain, Robert Potvin

The NEA Newsletter is published twice yearly in English and French by the OECD Nuclear Energy Agency. The opinions expressed in the Newsletter are those of the contributors alone and do not necessarily reflect the views of the Organisation or of its Member countries. Material in the Newsletter may be freely used provided the source is acknowledged. Correspondence should be addressed to:

The Editor, NEA Newsletter OECD Nuclear Energy Agency

12, Boulevard des Iles - 92130 Issy-les-Moulineaux, France - Tel: 33 1 44 44 06 44 ANNEA - Fax 45 24 11 10

The OECD Nuclear Energy Agency (NEA) was established in 1957 under the name of the OECD European Nuclear Energy Agency. It received its present designation on 20th April, 1972, when Japan became its first non-European full Member. NEA membership today consists of all European Member countries of OECD as well as Australia, Canada, Japan and the United States. The Commission of the European Communities takes part in the NEA's work and a co-operation agreement has been concluded with the International Atomic Energy Agency.

The purpose of the NEA is to further the development of the peaceful uses of nuclear energy by sponsoring economic, technical and scientific studies and projects, and by contributing to the optimisation of safety and regulatory policies and practices.
INFORMATION OF THE MEDICAL PROFESSION ON THE SUBJECT OF IONISING RADIATION

M. Tubiana

The OECD Nuclear Energy Agency organised, last September, an international seminar on information to the medical profession in the field of ionising radiation*. This seminar produced two and a half days of fruitful and rewarding debate. About 50 speakers — including doctors, journalists, academics, engineers and radiation protection experts — from nine countries presented highly detailed papers to an attentive audience which contributed many pertinent comments. A number of points emerged from the discussions:

**DOCTORS ARE AN EXCELLENT CHANNEL FOR PASSING ON INFORMATION TO THE PUBLIC**

They are both trusted by the public and responsible, either directly or indirectly, for almost all man-induced exposures to radiation. However, the question was raised as to whether it was possible to ask doctors to participate in informing the public. It seems that most doctors are prepared to do so since they feel concerned by the problem, if only when prescribing X-ray examinations. However, they do wish to receive specific training first.

Approximately 80 per cent of doctors consider that they do not know enough about the subject. In this respect, they feel much the same way as the educated public, although they have a far better understanding of the dangers of ionising radiation than other medical and allied professions (veterinary surgeons, nurses, pharmacists), because they have received at least a minimum of information on the subject during their medical studies.

Communication between doctors and the general public is poor in this field. Doctors are used to talking about illness and about methods of diagnosing and treating illness; they are not accustomed to discussing prevention and health risks. The general public does not understand the information offered, because no message can be taken in and digested unless some initial instruction in the concepts involved, no matter how basic.

has been given beforehand. Several commentators emphasised the desirability of providing some kind of basic instruction on risks and the environment at school level, even if ionising radiation was mentioned only in passing. The main point that needs to be put across is that risk should not be perceived as a qualitative concept (i.e. whether an agent is toxic or harmless, safe or dangerous), but as a quantitative one. Whether we look at means of transport (planes, cars, motorcycles) or sports (skiing, mountaineering, horse-riding, swimming), there is always an element of danger, but the degree of risk varies considerably according to the precautions taken, the experience of the person concerned, etc. The risks associated with almost all the potentially dangerous agents in our environment are proportional to the size and scale of the activity: the speed of a vehicle and the risk of an accident, for example, or the daily intake of alcohol and the probability of developing an alcohol-related disease.

In the field of technological risks, rejection is often based on qualitative criteria. As the facts become more fully understood, a return should be made to a quantitative criteria. As the facts become more fully understood, a return should be made to a quantitative approach, as this is the only way in which to avoid either overestimating or underestimating risks.

However, ionising radiation represents a somewhat paradoxical case. Of all the potentially lethal agents in our environment, radiation and smoking are probably the two which people are most knowledgeable about in terms of the potential risks and the type of damage caused. Also, the most stringent safety measures are undoubtedly those applicable to radiation. (In order to achieve a comparable level of safety on the roads, motorway speeds would have to be restricted to 5-10 km/h). Similarly, regulations applicable to radiation are much stricter than those applying to many chemical products. Despite all this, radiation is the hazard that is the most feared and most frequently overestimated, as borne out, for example, by the survey carried out in the

* This seminar, organised by the NEA in co-operation with the French Commissariat à l’Energie Atomique/Centre d’études nucléaires de Grenoble and Electricité de France, was held in Grenoble, France, from 2nd to 4th September 1992.

PROFESSOR MAURICE TUBIANA IS HONORARY DIRECTOR OF THE INSTITUT GUSTAVE ROUSSEY, IN PARIS. HE WAS THE CHAIRMAN OF THIS SEMINAR.
INFORMATION OF THE MEDICAL PROFESSION ON IONISING RADIATION

twelve Member States of the European Community. In response to these fears, the reaction of radiation protection specialists hitherto has been to increase the stringency of regulations. This increasingly cautious approach, however, has itself fuelled fears, resulting in excessively stringent, and increasingly expensive, precautions. The money spent on such measures could have been far more usefully employed in other areas. Moreover, the very fact that so much money is spent on protection makes people nervous, since they cannot help thinking that the danger must therefore be great. To allay such fears, even stricter regulations are introduced, creating a vicious circle that no one has been able to break for decades. It is now high time that all those involved in radiation protection gave serious thought to finding a way in which to ease some objectivity back into the perception of risk. Education at school should certainly play a key part in this new strategy.

EDUCATION IN RADIATION PROTECTION IS ALSO A NECESSITY FOR THE MEDICAL PROFESSION

Medical courses in all countries should include instruction on ionising radiation, especially since doctors are responsible for administering over 95 per cent of all man-induced radiation: X-ray and isotopic examinations, radiation therapy, etc. In addition to which, in industrialised countries, 50-80 per cent of the workers exposed to radiation in the course of their work are employed by hospitals. At present, such training varies considerably from one university to another.

Basic nuclear physics and biology should be taught either at pre-medical level or in the early stages of medical courses. More practical and clinical details such as epidemiological data, radiation protection standards, levels of dose delivered during X-ray examination, should be taught at a later stage in medical courses. It is essential that natural radiation be studied at the same time as the use of radioactive isotopes in medicine or industry. The human body makes no distinction between these three sources, whose biological effects are exactly the same. Differentiating between them in information materials is a mistake which has helped to foster the myth of the good atom (as used by doctors) and the bad atom (used by industry), as well as to propagate the view attaching greater importance to a dose of 0.001 millisieverts (mSv) from an industrial source than to a 0.5 mSv dose from a medical source.

Such instruction should also introduce students to concepts that are of use in other fields, such as the dose-response relationship and its extrapolation towards the lower end of the scale, showing how, depending on the shape of the dose-response curve and the choice of either optimistic or pessimistic assumptions, the risks associated with low doses can vary substantially from zero to an upper limit. Far from glossing over the uncertainties, it is essential to provide a clear definition of their limits and to illustrate, for example, the difference between a cautious estimate made for the purposes of radiation protection regulations and a realistic assessment. One example, a clinical problem frequently encountered in radiation protection, will illustrate this point: a woman who receives a dose of radiation during the initial weeks of pregnancy, usually as a result of an X-ray examination before she knew, or was willing to admit, that she was pregnant. The dilemma this raises is whether or not she should have an abortion. The corpus of medical experience shows that below 100 mSv delivered to the foetus, the risk, where there is one, is so small that it can safely be disregarded, and the pregnancy should therefore be allowed to proceed; above 200 mSv, it would be wise to terminate the pregnancy: between the two levels, the doctor should discuss the matter with the couple, advise them to proceed with the pregnancy, but depending upon the wishes and fears of the mother, agree to a termination if that is what they want. But just what is the level specified in radiation protection regulations? Until 1991, the maximum permissible dose to a pregnant woman in the course of her profession was 10 mSv: the level now proposed under the new regulations is 1 mSv. The difference of 200 per cent between the already highly cautious level prescribed by doctors and the level specified in radiation protection standards illustrates the distinction between a realistic assessment of the risk and a pessimistic assessment made for regulatory purposes.
Refresher courses are another essential, although less straightforward part of medical education. Any instruction on radiation, which is a topic usually removed from everyday medical concerns, is likely to be swiftly forgotten. It therefore needs to be repeated at periodic intervals. Since individual circumstances and receptiveness to ideas vary considerably, a wide range of channels is required: brochures, papers in medical journals, conferences to raise awareness, one- or two-day refresher courses for small groups. Whatever the format adopted, the teaching staff must be credible. For doctors, the obvious choice is therefore either university lecturers or hospital specialists. It should not be forgotten that the constant barrage of sales material to which doctors are subjected by the pharmaceuticals industry tends to make them sceptical of outside sources of information, which is doubtless why both official and industrial organisations have less credibility than university lecturers and specialists. Nonetheless, such bodies do have a significant role to play. Visits to industrial facilities and personal contacts between doctors working in nuclear facilities and their colleagues in other sectors can be extremely rewarding, particularly at local level.

The problem with specialists is far simpler. They generally recognise the need for instruction, and their motivation is high. The problem is to decide what level of knowledge should be aimed for. It would reasonable to demand a relatively advanced level of knowledge in the area of radiobiology and radiation protection, not only for radiologist-radiotherapists, but also for all doctors who use radiological techniques (gastro-enterologists, cardiologists, etc.). Optional advanced courses are essential for doctors specialised in occupational medicine who are responsible for monitoring workers exposed to radiation.

As for specialists in radiation protection, a problem surfaced on several occasions in the course of the discussions, namely that of the danger of a conflict between practitioners who use ionising radiation every day as part of their normal medical activity, and specialists in
radiation protection whose understanding of
the effects of radiation on the human body is
of a more theoretical nature. Links should be
forged between these two disciplines. Clinical
practitioners should acquire a good basic
understanding of the theory. It would also be
helpful if specialists in radiation protection
were to be given practical training in hospitals
involving the examination of irradiated
patients who have received doses ranging from
1 mSv to 60 Sv, and to monitor their progress
alongside clinical practitioners. This mingling
of theory and practice would improve the
dialogue between the two camps, avoid their
talking at cross-purposes, and might help to
define more realistic objectives in the area of
radiation protection.

DISSEMINATION OF INFORMATION IN
AN EMERGENCY

Chernobyl is still fresh in people's minds and
everyone wants to use it as a basis for drawing
up new procedures. All participants acknow-
ledged that relevant information could only be
properly given and understood by doctors who
had received at least some basic training and
who already had at their disposal
documentation supplied from a reputable
source, i.e. written by respected figures who
are known for both their competence and their
objectivity.

In the event of an emergency, it is important to
set up such a group. An international group
would carry even more weight. The main
thing is to avoid inconsistency. Several cases
were mentioned. For example, in the
aftermath of Chernobyl, Finnish experts set the
maximum permissible concentration of
caesium in reindeer meat at 3 000 becquerels
per kilogramme (Bq/kg), compared with the
level of 1 000 Bq/kg set by their Swedish
counterparts: in another example, a British
expert interviewed on television stated that
"the radiation levels in milk present no danger,
but avoid giving milk to young children".
Public information, particularly in an
emergency, cannot be improvised, it needs to
be prepared beforehand. It must be proactive
rather than reactive.
CONCLUSION

A general consensus was reached on three practical recommendations:

1. Some course of instruction on radiobiology–radiation protection should be included in the medical training syllabus. Any such instruction should be part of both the radiology syllabus and a broader course embracing preventative medicine and the impact of the environment on human health. This would allow students to gain an overall perspective of the various risk factors to which man is exposed, as well as an understanding of the more general concepts of epidemiological research, the dose-response relationship, and protection standards.

2. Such instruction should also be dispensed in various forms to members of the other health professions (pharmacists, veterinary surgeons, nurses, etc.), and in a more basic form to all primary and secondary schoolchildren.

It would be helpful if an OECD working party were to make some practical proposals in these areas.

3. Research should be encouraged in numerous areas such as:

b) Pedagogical research to tailor courses to students’ requirements.

c) Research into how risks are perceived, to find out how irrational fears can be overcome and fallacious thinking corrected in cases where risks have either been underestimated (smoking, exposure to sunlight, road transport, avalanches, etc.) or overestimated (as in the case of certain chemical substances, such as dioxin, or radiation).

Any distortion in the assessment of risks in a democratic society can lead either to unwise actions or to irrational behaviour and financial waste, which is doubly unfortunate in that the sums of money available for making the environment safer are not unlimited. An accurate and fair assessment of risks is therefore an essential component of education in modern society. The medical profession is in an ideal position to help society gain such a better understanding of the concept of risk.
PARTITIONING AND TRANSMUTATION OF ACTINIDES

The question of partitioning and transmutation of actinides is currently the subject of renewed interest within scientific and political circles, notably in the context of the search for solutions to the problems related to the management of long-lived radioactive waste. In 1990, the Nuclear Energy Agency launched an International Information Exchange Programme on Actinide and Fission Product Partitioning and Transmutation. Meanwhile, on two occasions, the NEA Radioactive Waste Management Committee has published a statement putting into perspective the way in which research in this field should be viewed from a radioactive waste management standpoint. These statements by the NEA relevant Committee are reproduced alongside the article by Dr. Abrahams describing the subject.

TRANSMUTATION OF LONG-LIVED NUCLEAR WASTE
K. Abrahams

INTRODUCTION

The possibility of converting nuclear waste into harmless or even valuable material has recently been used as an argument in the public discussion on new waste treatment strategies. The OECD Nuclear Energy Agency (NEA) and the Commission of the European Communities (CEC) have been encouraging national research institutes to organise the study of new transmutation methods in an international network. This new exercise in modern alchemy was initiated by Japanese efforts in the OMEGA project, which stands for "Options for Making Extra Gains from Actinides". This research is not considered as a substitute for continuing studies on the management and disposal of radioactive waste, but rather as a means to develop a possible complementary approach. By now it is generally recognised that an integration of transmutation methods in the nuclear fuel cycle could reduce the long-term toxicity of commercial waste and also allow for a cleaner transmutation of plutonium from the expected decommissioning of nuclear weapons. An extra benefit of this more economic use of fuel could be a reduction of the risks due to uranium mining.

In ancient times, compounds of uranium were used as an additive in a process to produce yellow glass. Chance will only favour the prepared mind, and it was Becquerel who "accidentally" discovered the radioactivity of uranium in 1896 by means of newly developed photographic techniques. This discovery was followed by rapid advancements in nuclear physics and technology, which culminated in the introduction of electronuclear power by neutron-induced fission. In this process, heat is liberated by fission of uranium into waste products. Spent fuel mainly consists of the uranium remains (usually as an oxide), contaminated with fission products and traces of actinides produced by the capture of neutrons in the uranium. Fissile actinides like plutonium and uranium can be recovered, whereas the remaining radioactive wastes can be vitrified into borosilicate glass, which guarantees their long-term retention, and permanently stored in underground repositories. Geological repositories have been shown to be reliable for many millions of years, as in the case of gas and oil deposits enclosed in old airtight geological formations. On the other hand, the fact that fossil fuel can be extracted also demonstrates that human intrusion cannot be entirely ruled out.

Long-lived nuclear waste emits radiation for thousands of years, and the moral issue is being raised that the long-term risks should be reduced. Our descendants may neither be in a position to profit from electronuclear power nor be aware of the waste repositories, which may be ancient by then.
Therefore, the radiotoxicity of the waste should be “ALARA” (As Low As Reasonably Achievable), and it is worthwhile to find out whether one could develop clean, safe and economical methods to eliminate some of its risky components. Just like transmuting uranium in a reactor, one could in principle learn to transmute waste, and reduce its long-term radiotoxicity to the level of the original uranium ore. Aspects of risk, energy and resources should be considered before decisions are taken on how far one should go.

The discussions of risk are usually focused on high-level waste, like spent fuel or toxic leftovers from the fuel cycle. Any comparison with the risks of the original uranium ore emphasises the radiotoxicity of the long-lived transuranic elements, or actinides. Figure 1 (from ref. 1) shows how the radiotoxicity of high-level waste decreases by decay. As can be seen, actinide toxicity will remain high for a very long time, unless the waste actinides are removed and transmuted.

**FIGURE 1.** DECAY OF THE RELATIVE TOXICITY OF SPENT FUEL

![Graph showing decay of radiological toxicity](image)

**RADON GAS AND MINING RISKS**

Globally, the radiation risks due to natural radon gas in dwellings and to the potassium in food exceed by far the present radiation risks from stored high-level nuclear waste. Radon is a decay product of the natural uranium in the soil, which leaks to the surface while it decays in a few days. It is revealing to realise that the radon dose rate is about 50 per cent of the total radiation dose rate to which mankind is exposed, and that this dose rate would disappear in the very unlikely case that all natural uranium on earth would be removed or well covered. This paradox has been phrased as: “uranium: don’t leave it in the ground”. In the meantime however, the uncovered uranium mill tailings from the mining process and the emanations thereof are radiological risk factors of the nuclear fuel cycle, which cannot be neglected. Although the radiotoxicity of uranium ore is more
than a thousand times less than that of the spent fuel (see fig. 1), the volume of mining wastes is much too high to consider vitrification followed by deep storage in geologically stable repositories. Therefore one should limit the quantity by applying a much more efficient utilisation of the uranium and of the heavier actinides. The above-mentioned phrase could be modified to say, "uranium: fission it entirely or leave it deep in the ground".

More efficient use of fuel will not only reduce the need for mining and transportation, but it could also reduce the long-lived radiotoxicity of high-level waste. Combining better fuel utilisation with actinide transmutation would be a way to limit the production of long-lived toxic waste.
PARTITIONING AND TRANSMUTATION OF ACTINIDES

RISKS FROM MOBILE COMPONENTS

Just like radon gas leaks out of uranium waste, there also are other geochemically mobile components that may leak out of deep repositories towards the surface. In contrast with the case of radon, which decays in a few days, some of the long-lived waste elements give a high contribution to the dose rate for up to millions of years. Special candidates for transmutation are therefore fission products such as technetium (Tc-99), iodine (I-129), and cesium (Cs-135), as well as actinides such as neptunium (Np-237) and its precursors. Table 1 (references 3,4) shows, for a hypothetical set of unperturbed granite repositories, the global surface dose rate due to leakage of the stored amount of nuclear waste from the total nuclear production over the next 300 years (relative to dose rates from natural radiation).

<table>
<thead>
<tr>
<th>Storage period</th>
<th>One million years</th>
<th>Hundred million years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vitrified</td>
<td>Direct storage</td>
</tr>
<tr>
<td>Tc-99</td>
<td>100 %</td>
<td>98 %</td>
</tr>
<tr>
<td>I-129</td>
<td>–</td>
<td>2 %</td>
</tr>
<tr>
<td>Cs-135</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>U-235</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>U-238</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Np-237</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Pu-239</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Am-243</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

The last line in table 1 indicates the dose rate relative to the natural background. In the case of direct storage, the expected average individual dose rate is less than 10 per cent of present natural dose rates. This is not marginal, as it would give a total dose to the world population of 5 000 million man-sieverts over a period of one million years. Proper vitrification of waste, however, would reduce the collective dose rate to 0.05 man-sievert per year, which leads to marginal individual dose rates. The contributions from uranium-235 and uranium-238 show that vitrification is even beneficial for uranium ore which has never seen a reactor! It can be concluded from this table that the surface dose rates due to leakage are negligible if the mobile waste components are properly vitrified. Nevertheless, a reduction of the long-term radioactive elements before storage should be advocated, mainly as a safeguard measure or to prevent the possible amplification of leakage doses due to intrusion or other external causes.

RECYCLING PLUTONIUM, URANIUM AND MINOR ACTINIDES

Not only commercial waste but also the waste from the decommissioning of nuclear weapons could yield considerable amounts of plutonium. Most of this could be transmuted and used for energy production, as it is hardly possible to guarantee safeguarding it for very long periods (one wants to
PARTITIONING AND TRANSMUTATION OF ACTINIDES

avoid visions of future mines for plutonium). Moreover, the recycling of plutonium with uranium in MOX (mixed-oxide) fuel could well be used to produce electricity without having to mine uranium. Use of commercially produced MOX fuel is considered in Europe and Japan.

Recycling studies invariably lead to the conclusion that long-lived minor actinides will circulate for quite a long time in the MOX uranium-plutonium cycle before the total production of minor actinides will diminish. Neutron interactions with uranium lead to neptunium in the waste. The amount of actinide waste can be limited by irradiation in a high neutron flux. A possible objective could be to achieve zero-growth of minor actinides during constant energy production. Because there is no cladding yet nor a fuel which can withstand the required irradiation dose, remanufacturing after reprocessing will be necessary. Long cooling periods for the spent fuel are required to limit the heat and the radiation during fuel handling. This however again leads to the formation of other long-lived waste by beta decay, and the shorter the cooling periods are, the better it would be. In this view, it is important to limit actinide storage to unavoidable traces within the fission product waste and to start recycling right away. In current commercial practice, however, one hesitates to handle hot spent MOX fuel, because of the associated severe conditions of radiation and heat.

Burner reactors, which allow continuous transmutation of minor actinides and fission products, are being considered as an option for the future. The various types of fuel that are being studied for these burners involve mostly minor actinides. Some samples of minor actinides have already been irradiated in the reactors in several OECD countries. Processes to transmute minor actinides need special techniques; these are being studied in a number of laboratories within OECD countries. In the USA, a generic system called Integral Fast Reactor (IFR) is being developed, in which pyrometallurgical reprocessing techniques are applied to metallic fuel for a fast reactor. This burner reactor is integrated in the fuel cycle, just as was shown for the OMEGA project in figure 2.

It is not possible to include transmutation of fission product waste in common fuel cycles, and special burner scenarios should be studied. Fission products might be transformed into less
PARTITIONING AND TRANSMUTATION OF ACTINIDES

harmful or even valuable materials by neutrons, and some groups are working on this solution. Such work is proceeding within the OMEGA project in Japan and the ATW project in Los Alamos, USA. Demonstration tests, for example at the Petten High Flux Reactor and the PHENIX reactor (in a moderated irradiation facility), are being prepared by the Dutch Energy Research Foundation (ECN) and the French Commissariat à l’Énergie Atomique (CEA), respectively.

Accelerators could also be used as the source of neutrons. In Japan and in the USA, some accelerator scenarios are being studied. Beams of accelerated protons can be used to create a neutron source in a spallation target, and the capture of neutrons could convert actinide waste into fuel. Accelerator Transmutation of Waste (ATW) is proposed by the Los Alamos Laboratories. In the USA, there is significant interest in the clean-up of military waste. Special techniques are also being developed to avoid the build-up of minor actinides during transmutation. For the very far future, hybrid reactor-accelerator systems are being considered in Japan and in the USA. By continuously feeding accelerator neutrons to sub-critical molten salt reactors, reprocessing of fuel and feeding-extraction of waste could be applied (reference 5) and thorium might be used as fuel. If this concept proves to be feasible, a very clean, safe, and almost inexhaustible nuclear fuel cycle can be foreseen. This is one of a number of interesting concepts whose engineering and economic feasibility needs more work to be properly demonstrated, and for which international collaboration is worthwhile.

INTERNATIONAL CO-OPERATION

The short-term benefits of transmutation of nuclear waste are marginal, but international networks can establish programmes on a really long-term period for future energy production schemes. A NEA network for the exchange of information between OECD countries has been created. A CEC network has also been set up to co-ordinate studies of targets and fuels by TU1 and KfK (Karlsruhe), by CEA and EdF in France, and by ECN-Petten in the Netherlands. Activities in the USA are concerned with the earlier-mentioned generic systems IFR and ATW. Outside the OECD, the Commonwealth of Independent States (CIS) in particular is showing interest in fast reactors to transmute minor actinides (such as curium).

ECONOMICS

The costs of all transmutation techniques seem high: figure 2 for example suggests that for the minor actinides, a doubling of the operations of the present fuel cycle would be needed, which would imply a higher cost. One could try to proceed in such a way that each step pays for itself, for example by exploiting precious metals in the waste or by more economic use of the energy which is stored in actinides. During the incineration of fission products, no energy is liberated and much care has to be taken to limit the cost of waste transmutation to values that are lower than, for example, the price of the original nuclear fuel.

CONCLUSIONS

Nuclear waste disposal in geologically stable repositories is considered to be safe and effective, and the assumptions leading to the very long-term predictions seem to be satisfied. As possibilities to perturb the repositories can never be entirely excluded, it could be an attractive option to reduce the toxicity of waste by supplementing the uranium-plutonium cycle with minor actinide-burning cycles. In this option, the amount of mining waste would be limited at the same time, because the uranium would be used more economically. It is of vital interest that efforts be internationalised in networks to make proper use of the experience from past civil and military programmes.
PARTITIONING AND TRANSMUTATION OF ACTINIDES

References


2. MUKAIYAMA T., GUNJI Y., Ibid. page 340.


4. ABRAHAMS K., Minimizing the integrated collective radiation dose and the transmutation of long-lived nuclear waste. Contribution to the OECD-NEA Specialists’ Meeting on Accelerator-Based Transmutation, 24-26 March, 1992, Paul Scherrer Institute, Würenlingen/Villigen, Switzerland.

STATEMENT BY THE NEA RADIOACTIVE WASTE MANAGEMENT COMMITTEE ON THE PARTITIONING AND TRANSMUTATION OF ACTINIDES (April 1992)

The concept of partitioning and transmutation of actinides (PTA) and long-lived fission products is currently the subject of long-term research in several OECD countries. There is also research conducted in this area by the Russian Federation. The PTA concept could, in principle, contribute to reduce the inventory of long-lived elements present in radioactive waste from the nuclear industry.

In this context, the OECD Nuclear Energy Agency took note in 1989 of the renewed interest for the PTA concept, which has been the subject of considerable research and assessment since the 1970’s, and decided to ask its Committee for Technical and Economic Studies on Nuclear Development and the Fuel Cycle (NDC) to follow progress in this field. An Information Exchange Programme on Actinide and Fission Product Partitioning and Transmutation was set up within NEA covering technical aspects of

- chemical processing of nuclear spent fuel, relevant to the separation of various elements from highly radioactive solutions; and

- transmutation, linked to the fabrication of targets or mixed fuels, neutron studies and irradiation conditions in reactors or accelerators.

In 1990, a statement was prepared by the Bureau of the Radioactive Waste Management Committee (RWMC) putting this long-term research into perspective from a radioactive waste management standpoint. (This statement is reproduced below.)

Currently, technical and strategic (or system) studies are conducted in parallel. However, strategic studies are not advanced enough to evaluate the consequences of the application of a PTA strategy from the points of view of the construction and licensing of new industrial facilities, the short and long-term safety impacts, and the economic consequences. In particular, there are insufficient data on new waste inventories resulting from the application of a PTA strategy, as concerns the volumes of both low and medium active waste to be disposed of at or near the surface, and of intermediate or long-lived waste to be disposed of deep underground.

Under such conditions, the RWMC considers it premature to anticipate the possible consequences of PTA for radioactive waste disposal programmes as they are defined today. The statement adopted two years ago by the Bureau of the RWMC is still applicable and, at its meeting on 2nd and 3rd April 1992, the Committee emphasized once more that actinide separation and transmutation should not be considered as an alternative to geological disposal. This position does not prejudice the outcome of future system studies on PTA strategies. It is clearly necessary for the RWMC to continue consideration of any advances in this field and, if appropriate, in due course to assess the value of application of PTA to long-term waste management strategies.
STATEMENT BY THE BUREAU OF THE RADIOACTIVE WASTE MANAGEMENT COMMITTEE ON THE PARTITIONING AND TRANSMUTATION OF ACTINIIDES (April 1990)

At its last meeting, on 23rd-24th January 1990, the RWMC took note of the NEA Information Exchange Programme on Actinide and Fission Product Partitioning and Transmutation established by the Nuclear Development Committee, and reviewed the possible interest of this programme from a radioactive waste management standpoint. It was agreed at the meeting that the RWMC Bureau should prepare a brief statement on this subject for submission to the Steering Committee. The RWMC Bureau met on 28th February 1990, in Paris, and examined this topic in the light of the discussions at both the RWMC meeting in January 1990 and the meeting of the Bureaux of NEA Standing Committees, on 27th-28th February. The following statement was adopted which summarises briefly the views generally held within the radioactive waste management community about the separation and transmutation of actinides.

I. As a preliminary remark, it should be recalled that the geological disposal concept has been developed because of its potential to offer a practical and safe solution to the disposal of all types of long-lived radioactive waste, including high-level waste from spent fuel reprocessing, spent fuel itself if not reprocessed, and other miscellaneous actinide contaminated wastes (which represent greater volumes than the two previous categories).

II. Transmutation of actinides requires reprocessing of spent fuel and the subsequent separation of actinides from the resulting high-level waste solutions. Actinide separation and their transmutation into shorter-lived materials cannot be regarded as an alternative to disposal into deep underground repositories: several reasons may be mentioned:

i) Significant volumes of vitrified high-level waste exist already that are not in a form suitable for the separation of actinides;

ii) The relatively large volumes of actinide-contaminated waste, often referred to as “long-lived, intermediate level-waste”, are not candidates for an actinide separation and transmutation technology, in view of the technical and economical obstacles to the separation of their actinide content from the bulk of the material which they contaminate. Geological disposal has to be relied upon for this type of waste.

iii) The overall efficiency of an actinide separation and transmutation process for concentrated high-level waste is very unlikely to be sufficient to avoid leaving a “tail” of actinide-contaminated waste; in addition, a large amount of secondary actinide-contaminated waste would be produced. Geological disposal would be needed for these wastes.

III. In a radioactive waste management system involving the separation and transmutation of actinides, the total quantity of long-lived elements to dispose of would be reduced, as well as the levels of radiation exposure that might be received by populations living in the far future. However, when all radiological aspects (both for the general public and the workers involved) are taken into account in an overall assessment, together with other relevant nuclear safety, technical and economical factors, this benefit might be outweighed by the additional risks and costs introduced. On the basis of current knowledge, a radioactive waste management concept involving the separation and transmutation of actinides is not justified in the context of an overall risk/cost/benefit analysis. However, long-term safety studies being pursued, notably on the environmental behaviour of actinides, will allow a periodic re-examination of the validity of this conclusion.

IV. In summary, as actinide separation and transmutation cannot be considered as an alternative to geological disposal, research in this area should not be recommended or sponsored on that ground. Such research on the nuclear and chemical properties of the waste actinides should be seen as a useful addition to the general technical knowledge underlying the nuclear fuel cycle field. Recognising the existence of the NEA Information Exchange Programme under the Nuclear Development Committee, the RWMC stresses the need to place this Programme in a long-term research perspective.
SEVERE ACCIDENT MANAGEMENT: PREVENTION AND MITIGATION

B.W. Sheron and J. Royen

The concept of severe accidents in nuclear power reactors has evolved with time. A severe accident is usually defined as one which exceeds the design basis of the nuclear power plant sufficiently to cause significant damage to the reactor core. The design basis comprises basic specifications which ensure the capability of the plant to undergo a specified range of operational events, accidents, and external hazards within strictly limited radiological protection requirements. It usually includes the specification of challenging events (design basic accidents), important assumptions, and in some cases requires particular methods of analysis.

The severity of a severe accident depends on the timing and extent of fuel damage and on the timing and type of containment failure if containment integrity is lost.

SEVERE ACCIDENTS: PREVENT, MITIGATE, MANAGE

Before the accident at the Three-Mile-Island (TMI) plant in 1979, reactor safety considerations were mainly focused on design basis accidents. Since TMI, and especially since the Chernobyl accident, it is clear that the two keys to public acceptance of nuclear power are:

- the assurance that any reasonably credible accident will be controlled within the reactor containment, with no outside consequences;

- long periods of “normal” nuclear plant operation — that is, without any serious incident — including the implementation of waste management solutions.

In OECD countries — and increasingly in other countries as well — consideration of severe accidents is now an integral part of the general reflection on matters of nuclear safety. The need for procedures and technical means to cope with them is recognised. Although technical solutions may be different, as they are applied to different reactor systems, the underlying strategies to cope with these rare but potentially high-consequence events should be similar and compatible, all the more so as severe accident consequences — and public fears — do not know national borders. A joint approach to severe accidents has emerged progressively, contributing strongly to the shaping of national policies and regulations.

The first priority is naturally to prevent accidents — accidents within the design basis as well as severe accidents — from happening, and to prevent design basis accidents from developing into severe accidents. Accident prevention includes: reducing the frequency or severity of challenging events; improving the reliability of plant equipment needed to respond to challenges; and the use of automatic or operator action, based on reliable instrumentation, to control events before severe core damage occurs.

Accident management, defined as those actions taken by the plant staff during the course of an accident to prevent core damage, terminate the progress of core damage, maintain containment integrity, and minimise off-site releases, is considered of the highest importance at all stages of accident progress, from initiation to long-term control. Examples of measures that may be involved include procedures (i.e. plans, prepared in advance, involving human actions to accomplish certain operational objectives or to respond to actual events or to new information), ad hoc plans, analyses, outside specialist help, special equipment, communications, etc.

WHERE DO WE STAND REGARDING SEVERE ACCIDENTS AND THEIR MANAGEMENT

The main conclusions of recent work can be summarised as follows:

- Because substantial safety margins were included in their design basis, current designs of light-water reactors are able to
cope with events that go well beyond the design basis, provided that appropriate preparatory measures are taken to make the most of the numerous safety systems in the plant. The capability of a plant to function in conditions well beyond the design basis provides a margin of safety which should be exploited to maintain control over events and minimise the consequences of potential severe accidents to the public.

- One cannot stress enough the overriding importance of accident prevention and accident management. Nuclear power plants have progressive barriers to limit the release of fission products to the environment in the event of a severe accident. These are the fuel cladding, the reactor coolant system boundary, and the containment. Strategies to prevent severe accidents from proceeding to core melt or to mitigate their consequences can be implemented at each of these boundaries. Mitigation denotes all measures taken to limit the radiological consequences of an accident, including: limiting release into containment; limiting release from the facility; reducing public radiation exposure by sheltering, evacuation, off-site cleanup, etc.

- The framework needed for successful accident management includes:
  
  • identification and implementation of accident management strategies and associated hardware modifications. The development of accident management strategies must be based on sufficient knowledge about plant characteristics and accident phenomena, as well as human performance, to allow decisions to be made;

  • determining information needs. Before guidance or procedures to restore degraded safety functions can be implemented, the plant staff has to be able to diagnose the problem and monitor the course of a severe accident from the earliest stages. Instrumentation must be sufficient to allow operations personnel to interpret the status of the plant;

  • developing training programmes to make plant personnel familiar with postulated severe accident conditions and recommended strategies. Operator training programmes must take into account accident diagnosis and management beyond normal operating transients and incidents. They must be frequently reviewed, to assimilate the most up-to-date knowledge. Operators must be made sensitive to severe accidents, and be given the ability to influence the course of a severe accident from the earliest stages;

  • providing technical guidance. The problem of integrating accident management actions into reactor operations, i.e. finding the optimum way to provide technical guidance, is closely related to training;

  • defining decision-making responsibilities within the plant organisation and within the emergency planning authority. Clearly established lines of authority and precisely defined decision-making responsibilities in the plant organisation are obviously important for successful accident management.

- Containments should play a major role in the management of severe accidents. The containment's primary function of confining radioactivity released from the primary circuit must always be given priority in its design, construction and the operations rules. Severe accident management and mitigation measures have the potential to substantially reduce the probability of large off-site releases requiring short-term response.

A NEW REPORT ON SEVERE ACCIDENT MANAGEMENT

At the request of the Nuclear Energy Agency's Committee on the Safety of Nuclear Installations, the Senior Group of Experts on Severe Accident Management has prepared a report describing the status of accident management activities in OECD countries. This report, which will be published soon, presents the best information available from these countries on the current state of knowledge related to accident management issues. Specifically, it presents information on:

- the status of accident management activities in OECD countries.
SEVERE ACCIDENT MANAGEMENT

- description of various methods for integrating accident management into plant operations;
- elements of accident management;
- benefits of accident management and their quantification;
- basis for the development of accident management methods;
- conclusions and recommendations for further effort.

Severe accident management activities are being carried out in all OECD countries with nuclear power programmes. However, there is considerable variation in the goals, the approach, and the scope of the research being conducted.

INTEGRATING ACCIDENT MANAGEMENT INTO PLANT OPERATIONS

Several alternatives exist for integrating accident management activities into existing emergency response actions. Some available options include incorporating accident management into existing procedures, creating new accident management procedures, or providing general guidance rather than specific procedures. Each of these have their advantages and drawbacks.

Devising procedures for accident management actions would offer the advantage of providing the operating staff with instructions that were very specific and in a familiar format. On the negative side, such an approach could lead to inappropriate actions if a situation occurred which was not foreseen during procedure development. Procedures that are symptom-oriented can address this concern to some degree, but such procedures may be difficult to devise given the variety and, in some cases, the paucity of detectable symptoms produced by severe accidents.

Development of a guidance document is another alternative. This type of guidance might identify equipment, water supplies, and power sources needed to restore safety functions, but without providing the details of implementation. Such a guidance document

The PHEBUS-FP facility will investigate the behaviour of fission products during severe accidents in pressurised water reactors.
would allow consideration of the pros and cons of an action given the plant conditions as they are known. This approach would lead to a slower response than one which follows an explicit procedure, and would require the availability of more independent technical expertise.

Some accident management strategies may lend themselves better to one type of integration than another, and no single method of integration is likely to be best for every nuclear plant operating organisation. In practice, a combination of approaches may prove to be most effective, since the needs of the control room operator, support staff, and emergency management teams may not necessarily be best met by the same approach. An overall structure, which clearly delineates responsibilities and any transfer of responsibilities during the development of an accident, is the essential starting point.

Whatever the format chosen to implement its accident management programme, a utility must recognise the need to prepare to respond to severe accident events. Given the complexity of such events and the uncertainties introduced by the associated phenomena, this preparation should include cognizant engineering support to help the operator if adherence to procedures should prove ineffective.

**ELEMENTS OF ACCIDENT MANAGEMENT**

Several elements are needed for successful accident management. The ones currently implemented by most utilities consist of procedures or guidance, information needs, organisation and training, and co-ordination with emergency planning. While the form these elements take may differ considerably from one plant to the next, together they must form a coherent, co-ordinated whole at each plant.

During a severe accident, the plant staff observes symptoms or parameters that can
SEVERE ACCIDENT MANAGEMENT

indicate the status of certain safety functions. When these safety functions are degraded or lost, operators attempt to restore them. The ultimate aim is to restore the reactor to a safe, stable state that can be maintained in the long term. The plant staff's tasks therefore always involve the steps of diagnosis, decision, and action.

To implement these steps, the plant staff has certain information needs. Basic information is obtained from plant instrumentation which displays a number of critical reactor and containment parameters, allowing the operations personnel to monitor the plant and observe the effect of their actions. For severe accident management, two questions regarding instrumentation become crucial: what additional instrumentation is needed to satisfy operating needs during a severe accident, and can the needed instrumentation survive the environmental conditions?

The organisational structure used by nuclear plant owners varies widely from country to country and can differ among utilities in the same country. In general, during a severe accident, plant personnel will be reinforced by additional groups of technical experts, and responsibilities may be shared with outside authorities once the accident has reached a certain state. What is important is that organisational lines of authority during a severe accident should have been previously established and clearly defined.

Training, via instruction, simulators, drills and practice emergency exercises, provides another essential ingredient for adequate accident management preparation. A proper balance in training operators for severe accident situations needs to be maintained. It has been postulated that training operators in procedures specific to severe accidents to the same level of detail than for design basis accidents could unnecessarily burden them to learn procedures for very low probability events at the expense of learning and understanding procedures for more likely events.

Finally, on-site accident management must be co-ordinated with government agencies for implementation of emergency plans involving evacuation of the population surrounding the site.

BENEFITS OF ACCIDENT MANAGEMENT AND THEIR QUANTIFICATION

The benefits of accident management can be used to justify its implementation. Benefits can be assessed in various ways. Two areas are considered in this report: How can accident management improve reactor safety and further reduce public risk, and how can accident management increase the public acceptance of nuclear power plants? The quantification of benefits depends to some extent on how accident management goals are stated. A deterministic approach, listing requirements for safety functions and specifying release limits, is one way. Another is a probabilistic alternative, where numerical safety goals are stated for core damage frequencies and large releases. One way to quantify some benefit of accident management is to look at probabilistic safety analysis results for a particular plant. Reduction factors can be obtained by evaluating core damage frequencies and expected fission product releases to the environment with and without accident management actions. In these cases, the size of the uncertainties involved will determine how meaningful these factors are. To accurately assess the effects of accident management actions, their possible adverse impact must also be accounted for.

The benefit of accident management for public acceptance of nuclear power is even more difficult to assess. To some extent, accident management can be used to explain to decision-makers how risk can be further reduced. However, public opinion is not easily swayed by technical arguments over small versus even smaller probabilities. Nevertheless, it is important that the public be aware that there are a number of measures that can be taken even if a nuclear plant enters beyond design basis conditions.

BASIS FOR THE DEVELOPMENT OF ACCIDENT MANAGEMENT METHODS

A fundamental question for accident management research is “What new information could give new insights and provide the basis for alternative actions?” The basis
from which to develop accident management methods can be separated into general objectives and priorities, information on plant design and characteristics, knowledge of accident phenomena and progression, and the complexity of the man-machine interface.

Information on plant characteristics and response during an accident can be obtained from plant-specific probabilistic safety assessments. The relative importance of different accident sequences for a particular plant can thus be established. However, probabilistic safety assessments have their limitations, and deterministic analysis must also be used to understand design vulnerabilities.

FURTHER EFFORTS

Despite significant progress in understanding severe accident phenomena and progression, important uncertainties still exist. Additional research for accident management in this area must ask whether more detailed information will really change a strategy or help the plant staff in their decisions. For situations in which sizeable uncertainties exist regarding the favorable and adverse effects of specific actions, additional information may indeed be very helpful.

The complexity of the man-machine interface must also be considered in formulating accident management methods. The operators should have adequate instrumentation and computational aids to provide them with information during an accident. Questions arise as to how a particular individual or a whole organization will react to the stresses of responding to an abnormal situation.

Further efforts in accident management activities should concentrate on the identification and implementation of useful strategies, ensuring adequate information needs for proper accident management, providing technical guidance to plant staff, developing appropriate training programmes, and delineating decision-making responsibilities.
PARTICIPATION OF THE PUBLIC IN NUCLEAR ENERGY DECISIONS: WHAT ARE THE CONDITIONS?

R. Skjoeldebrand

Public acceptance of technology has become a key condition for its integration and use in nations at various stages of industrial development. People have a legitimate desire to be informed of the risks and benefits of a new industrial activity in their vicinity and to be associated with decisions. Likewise, there is growing public involvement in debating energy choices. This aspiration has been taken into account by most industrialised countries and has been reflected in various ways in their constitutional, legislative, and regulatory provisions. Although the principle is recognised, translating it successfully into practice means fulfilling certain conditions to ensure meaningful participation by those who stand to benefit.

In this context, the OECD Nuclear Energy Agency (OECD/NEA), in co-operation with the International Atomic Energy Agency (IAEA), organised an international seminar in Paris* where the issue of public participation in nuclear energy decision-making was debated among representatives of some twenty industrialised countries, including countries of Central and Eastern Europe. The objective of this workshop was to take stock of the nature and trends of national legal provisions and institutional procedures governing public participation in decisions regarding siting and operation of nuclear facilities in OECD and IAEA countries, and to compare them to those for non-nuclear installations. It also aimed to evaluate the effectiveness of different public participation formulae adopted in these countries, as well as the impact of public involvement on final decisions.

Dr. Skjoeldebrand, consultant to the NEA for this seminar, has summarised below the main conclusions of this workshop.

INTRODUCTION

A considerable amount of experience of public participation in decision-making exists throughout the world, not only in the nuclear sector but also in industry in general. It is clear that this experience is very different from one country to the other, and that it depends very much on the national legislative and political traditions. It is also to be noted that, for the time being, there is still little direct guidance on this subject to be found in the international treaties, though there are some pointers of significance.

There are, no doubt, some lessons to be drawn from the multitude of experience gained that could be of general value for the future, but some systematisation appears necessary in order to approach them in a logical manner.

Firstly, public participation may take place at different levels: the local and the national. The issues are different. At the local level, it is mainly a question of the siting and licensing of an industrial facility. At the national level, it is often the question of the future of nuclear power in general which is raised, possibly in the guise of a more specific issue. There are also different forms which participation of the public can take at each level.

There are different views on how to proceed towards public participation, how far it should be taken and how to make it meaningful. More important, perhaps, are the questions of how an orderly progression towards a true public consultation or participation can be achieved, and also of the important differences between public acceptance and public participation in decision-making. Finally, there are clear differences in the roles that elected representatives play at the local or municipal and at the national levels.

Industrial development and technological progress have led States to take on a role as guardian of public safety as well as security in the late part of the last and the early part of the current century. This brought with it procedures for consultation of the local public for siting of major and potentially hazardous industrial installations. The rules were not always very clear and occasionally seemed to serve not only the interest of the local population but also that of the proponent of a new project.

* The International Workshop on Public Participation in the Decision-Making Process in the Nuclear Field was held in Paris from 4th to 6th March 1992. The proceedings of the workshop will be published in early 1993.

DR. R. SKJOEDELBRAND IS A FORMER SPECIAL ASSISTANT TO THE DIRECTOR-GENERAL OF THE INTERNATIONAL ATOMIC ENERGY AGENCY.
DURING THE LAST TWENTY YEARS, A NEW TREND HAS EMERGED. ENVIRONMENTAL PROTECTION INTERESTS HAVE APPEARED. AT THE INTERNATIONAL LEVEL, THE STOCKHOLM DECLARATION OF 1972, THE FINAL ACT OF THE HELSINKI CONFERENCE IN 1975 AND THE GLOBAL NATURE CHARTER OF THE UN GENERAL ASSEMBLY OF 1982 HAVE BROUGHT OUT THE OBLIGATION TO INFORM THE PUBLIC, TO GIVE INDIVIDUALS A FEELING FOR THEIR RESPONSIBILITIES, TO STRESS THAT ALL CATEGORIES OF THE PUBLIC HAVE A RESPONSIBILITY TO CONTRIBUTE TO THE PROTECTION AND IMPROVEMENT OF THE ENVIRONMENT, AND TO MAKE IT POSSIBLE FOR EVERY PERSON TO HAVE THE POSSIBILITY TO PARTICIPATE, INDIVIDUALLY OR WITH OTHERS, IN DECISIONS CONCERNING HIS ENVIRONMENT. NATIONAL LEGISLATION HAS DEVELOPED IN PARALLEL IN MANY COUNTRIES WITH MUCH THE SAME CONTENT AND THE SAME OBJECTIVES.

THIS IS, NO DOUBT, ONE OF THE IMPORTANT FACTORS THAT HAVE LED TO THE DEVELOPMENT OF A NEW MENTALITY IN THE PUBLIC IN THE INDUSTRIALIZED AND IN MANY DEVELOPING COUNTRIES. THE PUBLIC NOW DEMANDS MORE INFORMATION AND ALSO MORE DIRECT PARTICIPATION IN THE MAKING OF DECISIONS CONCERNING THE ENVIRONMENT. FURTHERMORE, THE WORLD NOW FACES VERY SERIOUS ENVIRONMENTAL PROBLEMS, NOT ONLY AT LOCAL BUT ALSO REGIONAL AND GLOBAL LEVELS. THUS, THE QUESTION IS NOT WHETHER THERE WILL BE MORE DEMANDS FOR PUBLIC PARTICIPATION IN DECISION-MAKING IN THE FUTURE, BUT HOW SUCH PARTICIPATION CAN BE MADE MEANINGFUL AND SUCCESSFUL, AND LEAD TO DECISIONS THAT WILL NOT BE QUESTIONED AT A LATER STAGE.

THE DIFFERENT LEVELS OF PUBLIC PARTICIPATION

WHILE THERE SEEMS TO BE A GENERAL CONSENSUS THAT PUBLIC PARTICIPATION AT THE LOCAL LEVEL IN DECISIONS ON SITING AND LICENSING OF NEW FACILITIES IS DESIRABLE, OPINIONS ARE MUCH MORE DIVERSE ABOUT PUBLIC PARTICIPATION AT THE NATIONAL LEVEL, WITH REGARD TO DECISIONS CONCERNING FUTURE ENERGY PLANS AND, IN PARTICULAR, ABOUT THE FUTURE OF NUCLEAR ENERGY PROGRAMMES. IN COUNTRIES WHERE DIRECT DEMOCRACY, THROUGH PLEBISCITES AND REFERENDA, IS ANCHORED IN THE CONSTITUTION, SUCH AS IN SWITZERLAND, PUBLIC PARTICIPATION AT THE NATIONAL LEVEL IS, OF COURSE, ACCEPTED AND COMMON, BUT NEGATIVE EXPERIENCES HAVE BEEN NOTED REGARDING THEIR ULTIMATE EFFICIENCY (SMALL PARTICIPATION BY THE PUBLIC, MISUNDERSTANDING OF THE QUESTIONS ASKED, COUPLED WITH OTHER ISSUES ON THE BALLOT, ETC.).

IN OTHER COUNTRIES, WHERE REFERENDA ARE NOT SO COMMON, EXPERIENCE HAS ALSO BEENUNEVEN (SWEDEN, AUSTRIA, ITALY). THERE HAVE BEEN EXAMPLES OF ISSUES, EXTERNAL TO THE CENTRAL BALLOT QUESTION, PLAYING A MAJOR ROLE IN THE OUTCOME, AND THERE HAVE BEEN MISUNDERSTANDINGS ABOUT WHAT THE REAL ISSUE WAS. SEVERAL COUNTRIES HAVE PROVISIONS FOR PUBLIC INITIATIVES IN WHICH IT IS POSSIBLE TO FORCE A NATIONAL OR STATE REFERENDUM THROUGH COLLECTION OF A CERTAIN MINIMUM NUMBER OF SIGNATURES. THIS HAS LED TO REPETITIVE REFERENDA (SWITZERLAND, SEVERAL STATES IN THE USA) WHICH, IN TURN, HAVE CAUSED DISINTEREST AMONG THE GENERAL PUBLIC. THE SWISS EXPERIENCE INDICATES THAT THE REFERENDUM MECHANISM REQUIRES A SPECIAL DEGREE OF PUBLIC INFORMATION AND EDUCATION ABOUT ENERGY MATTERS IN GENERAL AND AVAILABLE OPTIONS AND THEIR COSTS AND BENEFITS IN PARTICULAR.

THE PUBLIC WISHES TO BE INVOLVED IN THE NUCLEAR ENERGY DECISION-MAKING PROCESS.

IN OTHER COUNTRIES, SUCH AS FRANCE, PUBLIC PARTICIPATION IN NATIONAL POLICY QUESTIONS TAKES PLACE EXCLUSIVELY THROUGH ELECTED PARLIAMENTARIANS. HOWEVER, EXPERIENCE IN SOME COUNTRIES HAS SHOWN A WIDENING GAP BETWEEN THE COMPLEXITY OF TECHNOLOGICAL PROGRESS AND THE ABILITY — AND WILLINGNESS — OF POLITICIANS TO TAKE DECISIONS ON SUCH DIFFICULT QUESTIONS AS NUCLEAR POWER PROGRAMMES. THIS NATURALLY LEADS TO WONDER ABOUT HOW THE PUBLIC AT LARGE WOULD BE ABLE TO TACKLE A COMPLEX ISSUE IF ELECTED POLITICIANS THEMSELVES ARE NOT ABLE AND WILLING TO DO SO.
On the other hand, public participation at the local level has produced a wealth of experience. Many, if not most countries, have a requirement that a public inquiry or hearing be held before a site use or construction permit can be given. The forms of such hearings and their framework vary, but they share the common characteristic of being consultative and not decisive. Their purpose is to give the local public a possibility to express opinions and objections, which are to be taken into account when an authority later takes the decision on the site or on the licence. The public normally has some degree of assurance that the opinions and objections given and the questions asked are taken into account. Experience shows, however, that the process may have some disadvantages:

- A “decide-and-defend approach” can foster adversary rather than co-operative attitudes;

- The question of who is “directly concerned” has much importance. A very liberal interpretation of that concept has led the same anti-nuclear groups to be present at all hearings. International interventions have been made in rather uncommon forms, foreign nationals have often been admitted to give their views, while elected representatives from local councils have been discarded as biased in favour of the project;

- When those concerned — however defined — consider that the legal process does not give them enough opportunity to voice concerns, they find other ways of conveying their views through petitions, media and demonstrations, etc.;

- The proponents often base their positions on technical and economic arguments, and they want these to be as complete as possible before the hearing takes place. This has meant that the project information is provided as late as possible in the process, which gives the public little time to study it. It has also been claimed in many cases that the local social and environmental factors have not been given enough consideration;

- The local public often feels that the process is too much one-way, with no guarantee that local concerns are taken into account in the final decision. The acceptability of the outcome therefore becomes questionable.

- The formality of the hearing process sometimes lends itself to procedural bickering, which delays the proceedings and can lead to legal litigation in courts on procedural rather than substantive questions;

- There have been some cases where the procedural possibilities of the consultation process have been abused to the extent that it amounted to corruption of the legal process;

- It is recognised that in a hearing, the most vociferous is the opponent and those who are willing to accept a project are unlikely to speak up. The net impression can thus be one of massive resistance, which may not impress the judge or chairman but which can be reflected in media and thereby impress public opinion.

Even if the experience of the local consultation process in general has been positive, its drawbacks have led to conclusions that it can be counter-productive, and it has even been seen as the biggest obstacle to real public participation in the decision-making process. A major reason for this is that public consultation does not lend itself easily to creating a consensus. Some are now seeking new and less formal forms of public participation, in order to obtain a more direct participation of local authorities and the public in the decision-making, and to achieve compromises that may satisfy or at least be tolerable to all parties involved. An ongoing effort aiming at cooperation in decision-making on siting of a low-level waste disposal facility in Canada has so far given positive results.

Beyond the site selection and licensing stages, local participation could also be envisaged with regard to later operation and, in particular, safety questions and emergency procedures that would be important to the local public. This has been tried in the form of local safety or information committees, which give representatives of the local community a direct insight in the operations, safety and emergency planning at a plant. Although this cannot be equated with direct participation of the public, participation through local elected representatives allows a close and continuing contact with the community. The experience of such committees in France and Sweden has generally been very positive.
There are very divergent opinions about whether the nuclear industry and its installations should be seen as a special case or not. On the one side, it is said that nuclear power is perceived as posing unique threats. This seems to stem from the original weapons application and the ensuing secrecy about all nuclear processes and — perhaps even more — from a general fear of radiation and its delayed health impacts in the form of cancers appearing decades after exposures. The same can however also be said about other advanced technology industries. Biotechnology is one example. But clearly, the unique aspects of nuclear are positive ones if one refers to the principles that have been laid down for protection of workers and the public. These aspects are very advanced and conservative, but they are also difficult to comprehend. Nevertheless, they are being seriously looked upon as models for protection of the environment and the public in other industrial sectors, notably for the disposal of hazardous wastes. Also, the same objections against the consultation process can be raised in the context of non-nuclear industries. Thus, the problems, for the main part, seem not to be specific to nuclear installations.

THE PROGRESSION TOWARDS PUBLIC PARTICIPATION

Public participation in decision-making may be seen as involving different stages. First comes a stage of public information, including education. Experience, in general, suggests the need to be most careful in planning public information campaigns. However, it is necessary not to confuse public acceptance with public participation in decision-making. The latter requires an additional process, which in itself may influence the outcome.

The second stage in the process is the actual consultation of the public. At the local level, this most often takes place through a public inquiry or hearing, or at the national level it can be through a consultative referendum (e.g.,
Sweden and cantonal referenda on nuclear issues in Switzerland). Such consultations have considerable weight in later decisions, and it is troublesome to note how they have been influenced by external events in the past.

The third stage is the direct participation of the public in decision-making, normally through a referendum at the community, state or national level. It is interesting to note in this connection that referenda have rarely been made, if at all, at the community level, and in at least one instance (Finland), they were directly rejected by the municipal councils.

THE ROLE OF ELECTED REPRESENTATIVES

From what has been said so far, it is clear that the role of elected political representatives in public participation is different at the local and national levels. It seems to have been more natural and generally accepted at the local or community level, where the politicians have a closer and more continuous contact with the electorate. At the same time, it is also at this level that it is easiest to obtain direct contacts with the public. There seems to be an indication of easier and more open cooperation with politicians at this level, often leading to — but not substituting for — public participation in the decision-making. In Sweden and Finland, the municipal councils have the right to veto the siting of industrial plants within their communes if these facilities are perceived to have negative or dangerous impacts.

In some environmental circles, direct democracy, with its mechanisms of initiatives and referenda, seems to be the desired model for making decisions on environmental and energy questions, in spite of the rebuttals that they often have brought in the past. It should not be forgotten, however, that in many countries, the normal parliamentary system has worked well and decisions have been taken through that system, even if these were potentially unpopular with large sectors of the electorate. It should be no surprise that in such countries, a change towards more direct democracy is resisted. However, this is by no means true for all countries, not even in the western industrialised world.

CONDITIONS FOR SUCCESSFUL PUBLIC PARTICIPATION

In some cases, public consultation and participation may have yielded negative results. To improve the process, it is therefore useful to look at the ultimate objective rather than at how to meet existing requirements, and to determine conditions to make the process meaningful.

In this context, some basic conditions would appear to have general significance. They are:

- information, including education, which still seems so difficult to achieve;
- transparency;
- "la concertation", a very French concept without direct correspondence in English, but which may be defined as establishing a common understanding as a basis for all future work, even if it does not mean that there would be agreement on issues; and
- consultation and participation.

The information must be two-way, and it must be available early before plans and positions are fixed. It must be available to all without any discrimination, and it must be complete, with only such limitations as can be easily understood.

Transparency should apply not only to the information, but also to the institutions and to the process itself, which should be seen to be legitimate and fair to all parties.

A common understanding must be created as a basis for all discussions and for joint action in problem-solving, and for a give-and-take in decision-making. Imposition by one side, even if only perceived, is bound to fail, and one must therefore seek solutions that are tolerable to all parties.

Consultation and participation should be seen to be fair. The process must contain possibilities to opt out, select among options or to have changes made.

What does this mean in practice? At the national level in some countries, referenda and initiatives are provided for in the constitution and the elements can not easily be changed. The importance of information and education
for that process must be stressed again. Media undoubtedly play an important role, both informative and educational. Fairness, competence and correctness would be desirable, but are not always found. There is also certainly a wish to put the threshold for such initiatives high enough so as not to encourage repetitiveness leading to disinterest among the public, and to require continuous and intensive education programmes.

Except in limited circles, there seems to be no general wish to expand the use of referenda, as they are seen to be risky. There seems to be a feeling that if local participation can be successful, this would make the consultation at the national level unnecessary if it not required by the constitution.

For local public participation, one can formulate some general conditions of a practical nature:

- There are normally some requirements for public consultation at least at the local level, but a proponent should not feel limited only by these requirements, neither in substance nor in the time limits given.

- There are normally requirements for the provision of information to the public on the project, but again the proponent should not feel limited by predetermined formal requirements; he should provide — and seek — any information needed.

- The proponent could voluntarily seek new ways to achieve a less formal consultative process, with the aim of creating a two-way exchange and of reaching compromise decisions with the participation of the local public and their elected representatives.

- The public consultation process should start as early as possible and before final plant information and site analysis are available.

- The consultation process could well start with several municipalities, rather than waiting to select the one that offers the most promising site.

- Local social, economic and environmental concerns must be given due weight.

- The process must be seen as developing between all parties and being fair to all. "Group decision" experience is relevant in this context.

- In this kind of process, fulfilling the formal public hearing requirements may well seem to become secondary, but it is, of course, still essential. The formal process must avoid excessive procedural discussions and subsequent legal actions in court on non-substantive matters.

- Costs may be perceived as high for such a process, but in view of past experience, it should be recognised that the formal approach may well involve much higher costs because of the delays it may incur.

CONCLUSION

The diversity of experience between different countries in this area is striking, and some countries are obviously seeking guidance on these questions. It may be time to develop some form of general guidance at the international level which can be used in specific national situations.
THE HELSINKI SYMPOSIUM — CURRENT ISSUES IN NUCLEAR THIRD PARTY LIABILITY

P. Reyners

This symposium on nuclear liability and the compensation of nuclear damage, the fourth in a series of international conferences organised by the NEA and the IAEA, offered some 200 participants an opportunity to take stock of the results of work in progress on upgrading the special regime applicable to nuclear third party liability. Participants were obviously aware of the negotiations that have been under way since 1989, under the auspices of the IAEA Standing Committee on Liability for Nuclear Damage, on revision of the Vienna Convention, work which once completed should logically be followed by similar amendment of the Paris Convention.

In broadening the scope of the symposium beyond the traditional circle of government experts, the organisers hoped to offer representatives of the nuclear and the insurance industries, as well as interested academics, a forum in which such issues could be discussed. The conference was not intended simply to initiate a debate among specialists, however. At a time when many countries from Eastern Europe and the South are now considering whether and how to become signatories to international conventions on nuclear third party liability, and to introduce the necessary legislation, this symposium offered them an opportunity to take part in the debate.

The work in progress in both Vienna and Paris is not restricted simply to updating the provisions of the conventions governing the liability and financial cover of nuclear operators as well as the procedures for payment of compensation. Another issue of major importance is the introduction of an international mechanism for the provision of supplementary compensation, once the basic insurance cover of operators has been exhausted, from funds supplied by the nuclear industry or even governments, as is currently the case in several OECD countries. With regard to the latter, it is worth noting that the provisions of the Brussels Supplementary Convention, which supplements the Paris Convention, are not matched by similar provisions in the Vienna Convention. Furthermore, one of the conclusions that some countries have drawn from the international impact of the Chernobyl accident is that any State which authorises the operation of a nuclear installation on its territory, at which an accident subsequently occurs, should itself be held partly liable for the payment of compensation for damage caused in neighbouring countries. The problem of damage to the environment at the international level, i.e. damage to the global commons, also still remains to be resolved. These items were therefore on the agenda of the symposium.

REVISION OF THE VIENNA CONVENTION

Unlike the Munich symposium, which had largely been devoted to analysis of the changes made in 1982 in the Paris Convention and the Brussels Supplementary Convention, the Helsinki meeting took place roughly halfway through the revision work on the Vienna Convention. Although the 50 or so countries taking part in this exercise largely agree that the Vienna Convention needs to be revised, some fairly significant differences of opinion still exist on certain points, and these were outlined in papers by several speakers.

One area of contention concerns the geographical scope of application of the Convention, where the argument that the Convention should provide protection solely to those countries that are Parties to the Convention is being countered by the argument advanced by several countries that protection.

---

1. The Helsinki symposium. Nuclear Accidents: Liabilities and Guarantees, was held from 31 August to 4 September 1992.
2. The previous conferences were held in Monaco in 1968, Stockholm in 1972, and Munich in 1984.
4. Only 14 countries are currently Parties to the Convention.
should be extended unconditionally to all countries, on the grounds that the potential victims of transboundary damage should not be denied a right to compensation. It has also been suggested that the scope of the Convention be amended to cover any future fusion reactors.

Another major issue concerns the definition of damage caused by a nuclear accident. Several recent conventions on compensation for damage caused by pollution — particularly marine pollution — are serving as a basis for a proposal that there should be explicit provision for damage to the environment as well as for the cost of measures taken to avoid or to minimise the effects of radioactive contamination, particularly in light of the controversy that surrounded the actions taken in western Europe in response to the accident at Chernobyl. A similar question arises with regard to compensation for economic loss, i.e. damage other than the loss of or damage to property. An example of this might be the loss of revenue sustained by certain sectors of the economy, the tourism industry for example, as an indirect result of the change in consumer behaviour brought about by a nuclear accident. Although the principle of extending compensation to such areas is relatively widely supported, it is still opposed by some countries that have more restrictive legal traditions. The possibility of establishing an order of priority for the allocation of compensation by type of damage, comparable to mechanisms already provided for in the legislation of various countries, is also being discussed.

Another topic directly related to the compensation procedure concerns instruments that might be used to facilitate the procedures whereby victims can lodge claims for compensation, particularly in the event of accidents affecting very large numbers of people — some of whom might be living in countries far away from the site of the accident. Participants discussed several proposed solutions whereby States might claim compensation on behalf of their citizens, for example, or international commissions or judicial bodies might be set up to assess the damage or even to settle claims for compensation in the place of the national tribunals that would normally be competent. However, for the time being, no clear preference was shown by any of the countries concerned.

The themes outlined above are only a brief indication of the numerous issues dealt with in the course of this symposium, to which we should add a number of papers on national experiences in this area given by countries not currently Parties to the Conventions (notably in the former Soviet Union, China, Japan and the United States).

**ISSUES RELATING TO INSURANCE AND SUPPLEMENTARY FUNDING**

There is little need to stress the key role that nuclear insurance pools have played in providing cover for nuclear risks since adoption of the conventions. Major issues such as the need to increase capacity in the third party liability market to match increased limits of liability, the provision of adequate funding to cover the costs of processing compensation claims in the event of accidents involving very large numbers of people, or the provision of cover for new risks such as damage to the environment, were ample reasons for dedicating an entire working session to them.

The State may intervene to provide compensation for the victims of a nuclear accident in two ways: as a substitute for the operator, in case of default by the operator who is liable; or by providing supplementary compensation to victims once the basic insurance cover has been exceeded, as specified in the Brussels Supplementary Convention. In respect solely of the latter, the disaster at Chernobyl in April 1986 provided a painful reminder of the urgent need, in view of the limited funding capability of operators and insurers in the current economic climate, to find new sources of funding for the payment of compensation for damage caused by nuclear accidents.

One novel aspect of the negotiations currently in progress, which has been prompted by the realisation described above, has been the search for a new mechanism that would combine funding from the nuclear industry as a whole with joint intervention by the Parties to the Convention, thus
relying on international solidarity to secure larger sums of money than the amounts currently available. Although this idea has gained widespread support, there are still numerous concerns of both practical and moral nature.

For example, some of the Parties to the conventions are opposed to the idea of setting up a system that would offer unconditional cover to all countries, arguing that their operators should be free to choose to enter into a mutual protection scheme solely with operators whose safety levels are felt to be compatible with their own.

The symposium thus offered an opportunity for a wide exchange of views and ideas on these questions between the Parties present.

INTERNATIONAL LIABILITY OF STATES

An entire working session was devoted to this topic, which despite the lively interest it aroused among many of the delegations participating in the Vienna negotiations, failed to progress as far as the review of the amendments to the third party liability regime.

Many of the international representatives attending the symposium would like to see legislation introduced in support of the work undertaken over the past few years by the United Nations Commission on International Trade Law on the liability of states for transboundary environmental damage caused by industrial activities judged to be dangerous. Moreover, a number of countries subscribe to the notion that governments which authorise and control nuclear activities on their soil should also bear part of the absolute liability for any damage that such activities might cause. Governments are held to be liable because of the leading role they play in regulating such activities, and what we see here is the conceptual link that some have established between liability and nuclear safety, on the grounds that an accident could only result from a failure to provide adequate regulation and supervision of nuclear installations. This approach is rejected by other countries, however, which consider that the liability for damage caused by nuclear accidents should be governed solely by private law, regardless of the level to which governments are committed to funding compensation.

CONCLUSION

The exchange of views* that took place in the course of this symposium clearly does not mirror the intergovernmental negotiations currently in progress, even though there is every reason to hope that it has helped participants to gain a better understanding of the complex issues involved and lent fresh impetus to the revision work in progress. Certainly, the numerous meetings and peripheral discussions organised during the symposium bear witness to the lively interest shown in this event by the various participants.

* The proceedings of the symposium will be published by the NEA in a few months time; they will include not only the full text of the papers given by speakers, but also records of the working sessions and round-table discussions, which played such a vital role in the Helsinki meeting.
BACKGROUND

For the last couple of years, a vast international effort has progressively been put in place through bilateral and multilateral actions to bring co-operation and assistance to central and eastern European countries (CEECS) and the New Independent States (NIS) of the ex-USSR. The main purpose is to assist the authorities of these countries in restoring an acceptable level of safety in the operation of those nuclear plants that were not shut down earlier, and to allow the nuclear energy programmes of these countries to contribute their expected share in electricity production.

Operating nuclear power programmes exist in Hungary, the Czech and Slovak Federative Republic (CSFR), Bulgaria and Lithuania, as well as in Russia and Ukraine. In other countries, nuclear power plants have either been shut down by parliamentary decisions (Poland, Armenia), or are still at the construction or commissioning stage (Romania).

Most of the nuclear power plants are located in the NIS, where they cover about 13% of the electricity needs. In some CEECs, the contribution of nuclear energy to electricity production reaches as high as 50% (Hungary), 35% (CSFR) and roughly one-third (Bulgaria).

Most nuclear power plants in the CEECs and NIS are based on two Soviet designs: the VVER pressurised water reactor and the RBMK graphite-moderated reactor.

There are roughly 50 VVER-type reactors in operation or under construction. The older ones (VVER 440/230) do not have all the safety features required under internationally accepted safety standards. Safety reviews have been carried out by the International Atomic Energy Agency (IAEA), and the World Association of Nuclear Operators (WANO) and others have provided direct operational assistance. A list of recommendations and proposed upgrades has been issued. The next two generations of VVER reactors (VVER 440/213 and VVER 1000) come closer to international safety standards, but nevertheless require major improvements.

The other type of reactor (RBMK), of which 15 are in operation on five sites in Russia, Ukraine and Lithuania, gives rise to even more serious safety concerns. Substantial improvements have already been put in hand by the international community following the Chernobyl accident, mainly under bilateral agreements, and the IAEA has launched an overall safety review of this reactor type.

There is also a focus on upgrading the "safety culture" in these countries, by going beyond technical improvements of power plants. Training activities are being set up, as well as improvement of the capabilities of independent safety and regulatory authorities.

Finally, upgrading programmes have to be drawn up as regards the nuclear fuel cycle, mainly in relation to waste management.

INTERNATIONAL CO-ORDINATION

At their last summit in July 1992, the leaders of the G-7, the group of the seven leading industrialised countries, offered their support within the framework of a multilateral programme of action intended to improve the safety of the nuclear power plants in these countries.

This safety programme is composed of immediate and longer-term measures. The first category is concerned with operational safety improvements, near-term technical improvements to plants based on safety assessments, and the enhancement of the regulatory regimes, mainly for the benefit of the RBMK and the VVER 440/230 which should not be operated any longer than absolutely necessary in view of their serious safety deficiencies.

The second set of measures is aimed at creating the basis for longer-term safety improvements, by examining the scope for replacing less-safe plants by the development of alternative energy sources as well as by more efficient use of energy, and the potential for upgrading plants of more recent design such as the VVER 440/213 and the VVER 1000. This should be completed within about five years and could involve major capital investments.
The implementation of the immediate measures has been placed under the "G-24" (which is a group composed of the Member countries of the OECD), the Secretariat of which is entrusted to the Commission of the European Communities (which is itself conducting assistance programmes entitled PHARE and TACIS). In addition, a supplementary multilateral mechanism is to be set up to address immediate operational safety and technical safety improvement measures not covered by bilateral programmes.

To cover the financing needs, the international community has been invited to contribute to a fund to be co-ordinated by the G-24 and the European Bank for Reconstruction and Development (EBRD). The World Bank is also called on to study the replacement of energy strategies and the corresponding cost implications.

THE CONTRIBUTION OF THE NUCLEAR ENERGY AGENCY

Against this broad background, the NEA has launched a specific co-operation and assistance programme for the benefit of CEECs and NIS, taking fully into account the efforts already under way elsewhere. The NEA is, of course, present in the co-ordination mechanisms described above, to which it brings its specific expertise.

A major component of this NEA programme of assistance and co-operation concerns the enhancement of nuclear safety and regulation in the countries concerned, and the provision of a legal framework for nuclear activities as well as the development of an adequate international nuclear third party liability regime.

Transfer of Nuclear Safety Knowledge

Invitations are routinely extended to CEECs and NIS to take part in specialist meetings, seminars and workshops on a range of nuclear safety issues, such as instrumentation for severe accident management, living probabilistic safety assessment (PSA) applications, nuclear power plant instrumentation and control, regulatory requirements and experience related to pressurised water reactor steam generators.

Interested countries also participate in International Standard Problem Exercises run by...
the NEA, dealing, for example, with fracture mechanics of structural components, reactor thermal-hydraulic transients, fuel damage accidents, fuel melt, loss-of-coolant accidents typical of Russian-designed VVER 440 reactors, etc.

Recently, the CSFR joined two major NEA cooperative projects: the OECD Halden Reactor Project, which specialises in reactor fuel behaviour, material ageing, water chemistry and instrumentation, and man-machine interaction, and the International Co-operative Programme for Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Projects.

Safety of VVER 1000 Reactors

In support of the IAEA programme in this field, the NEA will bring its specific expertise to the enhancement of the capability of these reactors to cope with severe accidents, notably with regard to the reliability of safety systems, the quality of steam generators and the reliability of on-line maintenance of automatic shutdown systems.

Strengthening of Safety Authorities

Through the members of the NEA Committee on Nuclear Regulatory Activities (CNRA), direct help will be provided to experts and officials of the countries concerned on specific regulatory issues. As a first step, arrangements have been made for a regular exchange of views between CNRA and the Council of regulatory bodies for VVER reactors, which groups representatives of CEECs, NIS, and OECD countries which operate this type of reactor.

Decommissioning of Chernobyl Units 1, 2 and 3

The NEA Co-operative Programme for the Exchange of Information Concerning Decommissioning Projects provides information and practical assistance in the decommissioning of nuclear power plants and fuel cycle facilities. The Ukrainian State Committee on Nuclear and Radiation Safety has indicated interest in joining this project. The Chernobyl units would be the first large power reactors to be decommissioned within this international framework.

Enhancement of Nuclear Safety Research

This project is designed to assist the Russian and Ukrainian State Committees on Nuclear and Radiation Safety in planning and executing safety research programmes aimed at building up capabilities in safety technology pertaining to VVER nuclear power plants.

The safety of light-water reactors largely depends on the knowledge of basic thermal-hydraulic mechanisms. The verification of the efficacy of emergency core cooling systems and containments utilising the principle of pressure suppression, and the evaluation of safety margins and of accident management approaches, are among the main goals to be achieved. Experimental research and computer codes are needed in this context.

As a first step, a fact-finding mission visited several thermal-hydraulic test facilities in Russia and Ukraine during May 1992. The group consisted of experts responsible for the operation of integral thermal-hydraulic test facilities in certain OECD countries. The experts concluded that it would be appropriate to study the thermal-hydraulic behaviour of VVER 440/213 and VVER 1000 reactors, and the containment behaviour of the VVER 440/213 reactors. They further believe that — after completion — the operation of the facilities that have been identified for this purpose would allow the development and validation of the major safety-related computer codes, including those developed in OECD countries, and would provide the necessary experimental and analytical capabilities in Russia and the Ukraine.

Long-Term Isolation of the Radioactive Substances of the Chernobyl-4 Nuclear Power Plant

This project is aimed at exploring ways to isolate in the short and long term the radioactive substances of the Chernobyl-4 nuclear power plant destroyed in 1986, and to examine how both steps could be made compatible.
In order to determine the status of the knowledge about the existing sarcophagus and its contents, and to identify the projects that have been considered so far, a fact-finding mission visited the Ukraine in September 1992. The group consisted of senior experts in nuclear safety, radioactive waste management, radiation protection, and structural integrity, nominated by the competent NEA committees.

A list of specific questions was drawn up, which pertain to the material and radionuclide inventory, the physical description of the sarcophagus, the site conditions, the safety assessments and possible future risks, approaches to the short and long-term isolation already considered, and the national and international administrative arrangements already made or under consideration.

As a result of this mission and the information thus collected, a symposium is being planned in early 1993, which will bring together the expertise from the OECD area as well as the Ukraine and Russia, with a view to addressing the status of knowledge and the current safety and environmental situation at the Chernobyl-4 reactor, and identifying possible options for the short and longer-term isolation of the radioactive substances within the sarcophagus. The symposium is intended to develop a series of recommendations concerning the next steps to be taken towards the isolation of this material from the biosphere.

**Nuclear Law and Nuclear Liability**

In relation to nuclear law, the NEA has been working on establishing programmes of cooperation between it and various central and eastern European countries. These programmes include, for example, provision of information concerning both nuclear legislation of NEA Member countries and international standards, and provision of assistance to CEEC and NIS authorities in drawing up new national laws. To this end, missions have already been made by NEA personnel to Hungary, CSFR, Romania, Ukraine and Russia.

Preparations are under way to hold, in the second half of 1993, a training seminar on nuclear law and insurance for CEECs and NIS, to which it is intended to invite participants from CSFR, Hungary, Poland, Romania, Russia, Ukraine, Belarus, Bulgaria, and the Baltic Republics.

As of 1992, the NEA Group of governmental experts on nuclear third party liability has accepted to invite observers from CSFR, Hungary, Poland and Romania to its regular meetings. Consideration is being given to extending this invitation to Bulgaria, Lithuania, Russia and Ukraine in the near future.
In 1985, the Nuclear Energy Agency (NEA) set up the International Co-operative Programme for the Exchange of Scientific and Technical Information Concerning Nuclear Installation Decommissioning Projects. The basic objective of the programme is to promote an exchange of scientific and technical information between decommissioning projects in various OECD countries. This information includes project descriptions and plans, data obtained from research and development associated with participating projects, data resulting from the execution of project plans, and lessons learned from such execution. The programme also involves technical visits to the participating projects.

The programme, which is carried out under the direction of the NEA Radioactive Waste Management Committee, was formally initiated in September 1985 for a first five-year term, with an initial set of participants composed of 10 decommissioning projects from seven countries. It has since been extended for another five-year period, and now includes 19 decommissioning projects from eight countries.

The decommissioning projects involved in the programme range from commercial-scale nuclear power plants to experimental or demonstration reactors and fuel reprocessing facilities. The projects currently include 13 reactors of different types, four fuel reprocessing plants, one mixed-oxide fuel fabrication plant, and one radioisotope processing facility.

Of these 19 facilities, 12 are to be, or have been, decommissioned to what is called stage 3, namely total dismantling.

Due to this wide variety of projects and also because of the different prevailing circumstances and needs at the various project sites, the type of information produced and reported has been quite diverse. In the recently issued report on the first five years of the programme, the progress and achievements in six major technical areas have been surveyed. These include activity inventory assessments, decontamination methods, cutting techniques, remote operation, radioactive waste management, and health and safety.

Regarding the status of technology in these areas and the contributions the programme could be expected to make in the future, the report arrived at the following conclusions:

- The comparative success of activation calculations needs to be consolidated and expanded by a collection and collation of the available and forthcoming data. The situation of contamination modelling is considerably less developed than that of activation modelling.

- While the basic technical data on decontamination already largely exist, the programme is providing an opportunity to exchange cost and performance data in real project situations. In order to make the information accessible in a convenient form, it may need to be incorporated into an expert system so that, for any problem, the Project Manager is both guided towards the technically appropriate method and assisted in assessing the likely cost and efficiency of the treatment.

- Some extension of existing cutting techniques is required, particularly in the area of segmenting very thick pressure vessels. In spite of the considerable progress made, there is a continuing requirement to exchange practical data. A first step would be to collect and review the information already available within the programme on ventilation and filtration.

- Technical development of robotic arms and their associated control systems is proceeding in nearly all the participating countries. While it can be anticipated that fully remote systems will continue to be refined, made more versatile and become less difficult to use, it is in the area of semi-remote operations that the most widespread application can be expected. Remote viewing is an area where a considerable development programme has been and is taking place. The contribution that the programme can make is in the area of practical trial and evaluation.

- In the field of radioactive waste management, information exchange on radioactivity monitoring needs to be increased. In particular, those parameters that are relevant to the industrialisation of the monitoring process for the various systems in use should be reported.
Each participating project has tackled the problems of waste management within its own technical and legal environment. It is apparent that there is some difference in economic perception between the participants, techniques which are rejected as uneconomic by one being embraced by another. This suggests that it would be fruitful to compare the assessments which led to such differing conclusions and to identify the reasons for the divergence.

Although some potentially useful data have already been reported on the radiation doses associated with particular operations, further information is required on the activity levels and radiation fields before the information can be scaled for use in a predictive mode.

An important objective in the future will be to exchange experience on the effects of the expected introduction of lower individual dose limits as a consequence of the new ICRP recommendations, both on the methods employed and on costs for similar projects.

The first five years of this programme represent a watershed in the evolution of decommissioning into a mature technical discipline. The techniques and methods needed for the decommissioning of nuclear power plants and fuel cycle facilities are available and well-proven on a semi-industrial scale. Development work will now be primarily focused on extending the procedures to a fully industrial scale.

A major challenge for the future is to examine the opportunity that exists to collect, systemise and codify this information in a way that makes it readily and easily available to future (and ongoing) projects, thereby making an additional contribution to the industrialisation of decommissioning.
FUNDING SCHEMES FOR DECOMMISSIONING NUCLEAR POWER PLANTS

G.H. Stevens

A report published by the NEA in 1986(1) shows that decommissioning of nuclear power plants adds very little to the costs of nuclear electricity. This finding has been repeated in later analyses (2,3), although the absolute value of the decommissioning cost is expected to be substantial, possibly in the area of a few hundred million dollars for a 1 000 MWe light-water reactor. The latest NEA report on decommissioning costs(4) illustrates that there is a wide variation in the individual cost estimates for reactors in OECD countries, and reviews the sources of this variation. To a large extent, these do not arise from uncertainties in the engineering requirements, but from differences in the type of reactor to be dismantled and from differences in the scope of work, timing, and the regulations that will apply. A fuller presentation of this work was included in the Fall 1991 edition of the NEA Newsletter.

The main body of decommissioning work will be performed after the plant closure, in many cases several decades after the corresponding electricity generation. General equity considerations require that the consumers who benefit from the electric power production of a plant should bear the costs of its decommissioning at the end of its useful life. It is therefore desirable that the funds for the future decommissioning work should be required during the reactor’s operating period. For this purpose, plant owners are putting aside money as provisions for decommissioning, and a considerable sum has already been accumulated. The money is collected in the price charged for the sale of electricity.

However, the actual funding schemes implemented in OECD countries differ considerably. Some countries leave the financing scheme to the facility owners. In other countries, the funding scheme is legally established and is strictly controlled by the government. Some governments have a tax system which encourages the private companies to put aside money. The variation in the schemes is caused by such factors as the differences in national accounting traditions, and the different views on the financial stability of nuclear plant owners.

This article provides a brief overview of the funding schemes implemented in OECD countries for the decommissioning of private nuclear power plants, based on the information included in the 1991 NEA de-commissioning report(4) and that presented at the International Seminar on Decommissioning Policies, which was jointly organised by the NEA and the IAEA in Paris in October 1991.

GOVERNMENT PROGRAMMES

Some countries have an official funding scheme, in which the government fixes the amount of money to be put aside, specifies a funding scheme and controls the fund.

In Finland, the system aims at ensuring that sufficient assets exist at all times to cover future waste management and disposal costs for all nuclear waste producers. The two Finnish utilities, Imatran Voima Oy (IVO) and Teollisuuden Voima Oy (TVO), must each prepare annually an estimate of the future costs for nuclear power plant decommissioning and for management of all the wastes produced by the end of that year. The Ministry of Trade and Industry (MTI) reviews and confirms the assessed liability of the companies. The utilities pay corresponding fees into the Finnish State Nuclear Waste Management Fund (FUND), which is administered by the MTI. The total fund contributions have to be collected during the first 25 operating years of the nuclear power plant concerned.

For the year 1990, the estimates for the liabilities of the two companies amounted to about 5 000 million FIM (1 160 million US$), corresponding to about 45 years of reactor operation. As of April 1991, the cumulative fund contributions were 1 900 million FIM (440 million US$) for TVO and 600 million FIM (140 million US$) for IVO. Corresponding fees per unit of electricity were 0.014 FIM/kWh (3.3 mill/kWh) for TVO and 0.008 FIM/kWh (1.9 mill/kWh) for IVO.

The FUND invests the contributions through loans, and the interest collected thereon is credited to the accounts of the waste producer. For the outstanding liability, i.e. the estimated
future costs not yet covered by the contributions paid into the fund, the waste producers must furnish securities as a precaution against insolvency. If at any time a company's assessed liability to hold money in the FUND falls below the level of its actual account (for example, as a result of actual expenditure on decommissioning or waste management), then it will receive a refund.

In Spain, the approach adopted is broadly similar, depending on a system of payment on account. A levy of a predetermined percentage (named "quota") is made on electricity sales. The incomes resulting from the quota, including the accumulated interest on the fund, will meet the projected future expenditures for the complete management of the nuclear wastes (including low-level waste transportation and disposal, spent fuel and high-level waste transportation, storage and disposal, nuclear power plant decommissioning, reprocessing of gas-cooled reactor fuel, R&D and overheads).

The government annually establishes the value of the quota on the principle that incomes of one year are proportional to the electricity generated by nuclear power plants in that year. The target amount of the fund in 1991 was 800 million US$ (1990), which was calculated with an expectation that the fund would attract interest at a real rate of 3.5 per cent. In 1991, some 21 per cent of the total had been collected.

In Sweden, there is also a comprehensive official funding scheme with a fee being levied on the nuclear electricity production. The collected funds are administered by the Swedish Nuclear Fuel and Waste Management Company, SKB. One fund is set up for each reactor owner.

The fee is to be paid as long as the reactors are in operation, at a level set annually by the government for each reactor station. The decision by the government is based on a proposal by SKB, itself founded on a cost calculation by the plant’s owner for all the activities required to take care of the spent fuel and the radioactive waste, to decommission the reactors, and to manage the waste from decommissioning. In 1990, the total costs for

Classification of different parts of the Marcoule G2 reactor during dismantling.
the back-end of the cycle were estimated to be 53 GSEK (8 200 million US$). Of this amount, 11 GSEK (1 700 million US$) was attributable to decommissioning and management of decommissioning wastes. The total fee for 1990 was, on the average 0.019 SEK/kWh (2.9 mill/kWh), of which about 0.004 SEK/kWh (0.6 mill/kWh) corresponded to decommissioning costs.

The total value of the fund at the end of 1990 was 7.6 GSEK (1 200 million US$). Part of this money is used for the different waste management activities already under way, such as interim storage, transport, and research and development.

**GOVERNMENT/INDUSTRY PROGRAMMES**

In some countries, the government fixes the amount of money to be put aside and specifies the funding scheme, but leaves the management of the fund to the facility owners or an external organisation.

Under the agreement between the Belgian government and companies owning nuclear plants, provisions are established in the balance sheet of each company to cover the costs of decommissioning and decontamination of the nuclear facilities. Funds are raised through annual contributions during the plant’s lifetime (assumed as 20 years). Together with the interest accrued, these contributions must, in 30 years from the plant’s start-up, amount to 12 per cent of the initial investment currently needed to build such a plant. The interest calculation is based on rates customarily used for present-worth calculations. Annual contributions to the fund are taken into account in the prices per kWh of electricity.

The US Nuclear Regulatory Commission (NRC) requires nuclear power plant operators to establish a fund for decommissioning. Essentially, the requirement is to accumulate, in a segregated and external fund, a minimum amount in the range of 75 to 135 million US$ (1986) for each power reactor.

This is based on a specific formula for plant size and age plus an adjustment for escalation of costs. The stipulated coverage of the fund does not include costs specific to structural demolition or site restoration activities, because NRC requirements pertain only to the termination of the operator’s licence. The total amount of the fund is to be available at commencement of a power plant’s decommissioning. The fund is built up through the payments made by current utility users.

In Switzerland, a draft of new nuclear legislation was prepared in 1991, which calls for the owners of nuclear facilities to pay contributions to a fund that would cover the future costs for the safe storage of nuclear facilities after their service life and for management of the wastes. The fund would be placed under the surveillance of the federal government, and a committee nominated by the federal council would determine the contributions to be paid to the fund.

**INDUSTRY PROGRAMMES**

In countries such as Canada, France, Germany, Italy, Netherlands and the UK, there is no official funding scheme, and preparations for the future decommissioning expenditures are left to the owners or operators. The nuclear plant owners or operators responsible for decommissioning activities determine the amount of money to be put aside and take care of the provisions by themselves.

In Canada, the Atomic Energy Control Board (AECB) requires that utility companies develop their plans for decommissioning nuclear power plants with all associated actions assured by adequate financial planning. The utilities are setting aside decommissioning funds during station operation and charging an appropriate fee in their rate base in order to cover the costs of spent fuel disposal and decommissioning according to current technology and regulations. The required annual fee is calculated so as to build the necessary size of fund over the projected operating life of the station. The funds are self-invested in the utility.

Électricité de France (EdF) makes an annual provision in its accounts, calculated for each power generation unit, with the objective of
DECOMMISSIONING OF NUCLEAR POWER PLANTS

including in the electricity generation cost the full proportional contribution necessary for future decommissioning. The total liability for decommissioning is estimated to correspond to about 15 per cent of the construction cost of a nuclear power plant, which is updated with GNP indices. The required provision for a nuclear power plant in the year of commissioning is determined by a formula based on a reference cost that is proportional to plant capacity and the assumed plant lifetime (20 years for gas-graphite reactors, 30 years for pressurised water reactors). The provision is recalculated in later years according to an updated estimate of decommissioning costs, funds accumulated, and residual plant lifetime.

They may also decide whether they want to take the risk with or without an external insurance.

Japan does not have a national funding system, and the establishment of provisions is for the nuclear power plant owners to decide. However, Japan has a tax system that encourages the companies to prepare funds for future decommissioning; the tax system allows the owners to reserve, tax-free, up to 85 per cent of total decommissioning costs. As a reference, the decommissioning cost of a light-water reactor of 1 100 MWe was estimated to be about 30 billion yen in 1984 value.

The maximum annual reservation to which the tax exemption can be applied is calculated by multiplying the target amount of the fund for each unit, with the ratio of electricity generated in the year to the total electricity expected to be generated during 27 years of operation with an availability factor of 70 per cent.

In the Netherlands, the utilities are also responsible for the cost of decommissioning work and must set aside decommissioning funds during the operational lifetime of the plant. It is up to the utilities to estimate the size of the fund and the amount of annual contributions.

For the management and disposal of decommissioning wastes, the same regime is applied as for other radioactive waste. When the COVRA (Central Organisation for Radioactive Waste) collects the waste, utility companies have to pay charges for the COVRA's service of collecting, treatment and storage of radioactive waste. At the moment of actual transfer of the waste to COVRA, ownership of the waste is also juridically transferred to COVRA.

In the United Kingdom, Nuclear Electric and its predecessor the CEGB have, since 1978-79, made specific financial provision in their annual accounts for decommissioning nuclear power stations. These provisions are reviewed annually, taking into account inflation and the latest decommissioning cost estimates. During the operating life of a nuclear power station, provisions are made such that, at cessation of generation, there should be sufficient money to cover all stages of decommissioning, including the passive phase between stage 2 and 3.

In Germany, utilities are responsible for all decommissioning actions, including covering the full costs. Liabilities for decommissioning must be identified in the commercial company’s balance sheet in accordance with a legal prescription to build up financial reserves. The owners make provisions for liabilities and charges according to their own judgements.

Decommissioning of the Japan Power Demonstration Reactor.
Thus, although the approaches to implementation vary considerably between countries, there is in all of them a commitment to the principle that the money for future decommissioning should be accumulated during the reactor’s operating period.

References

ACCESS TO SOFTWARE FOR NUCLEAR TECHNOLOGY
N. Tubbs

Through its Data Bank, the Nuclear Energy Agency offers a direct Computer Program Service covering a very wide scope in nuclear technology. This service is provided both by the Data Bank itself for its 17 participating countries* and by two US software centres** for the USA and Canada, with an exchange of programs between the US centres and the Data Bank. It covers an extensive collection of nuclear software in the public domain, and is distributed by the NEA Data Bank without charge to users nominated by the authorities in the Member countries concerned.

THE SPREAD OF COMPUTER USE

Almost all the intellectual work associated with the physics and engineering design of reactors, including their operation, fuel management, safety assessment, licensing and final decommissioning, is carried out using computer methods. Increasingly, the results of scientific investigations in all the domains relevant to nuclear energy are expressed as computer files containing modelling programs and data. The results obtained are then fed into other programs downstream. Computer simulation has advanced to the point where in many areas, integral measurements are carried out above all to check the software and to make minor empirical adjustments to the input data.

It has always been important to have reliable software and to base calculations on data known to be sufficiently accurate for the application concerned. Validation of programs has grown in difficulty with their increasing size and complexity, but fortunately its importance is now widely recognised. As an example, many specialist meetings on nuclear energy topics are nowadays held in order to compare the success of competing programs in modelling the phenomena of interest, and are followed by corrections to the programs giving better convergence between the results obtained.

THE COMPUTER PROGRAM SERVICE

The Data Bank serves about 430 accredited institutions in the participating countries. These institutions may be national laboratories, nuclear engineering contractors and electricity suppliers, universities, private consulting companies, or licensing authorities. User institutions are nominated by national delegates to the Executive Group of the NEA Nuclear Science Committee (NSC), which is the supervising body for the Data Bank: each institute appoints a liaison officer to co-ordinate requests for service, who also ensures that software produced within his institute is where possible offered for distribution to other users via the Data Bank.

New programs offered to the Data Bank are advertised to other users in the regular publication News from NEA Data Bank. If this information results in requests for a program, the author institution will be asked to send it in for testing. The current collection of tested programs amounts to about 1500 program packages, which is refreshed by the addition of about 100 new programs (or new versions of programs already on file) each year, with relegation of older programs or superseded versions to an archive file. Programs from the USA and Canada are obtained on a reciprocal basis, with programs from the Data Bank countries being offered to the US software centres.

* These are the 17 Member countries of the Data Bank: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom.

** ESTSC = Energy Science and Technology Software Center
RSIC = Radiation Shielding Information Center

MR. NIGEL TUBBS IS DEPUTY-HEAD OF THE NEA DATA BANK.
Over the last few years, between 1,500 and 1,700 program requests have been answered each year, normally by sending out complete tested program packages; less frequently, documentation only is requested, or programs urgently needed may be sent out untested. A recent development is the availability of versions of many of the most frequently requested programs for mainframe computers, adapted for personal computers (IBM PCs and compatibles). Smaller countries are very active both in preparing these programs and in requesting them.

The two pie charts (figure) show the different subject categories and the proportion of requests answered during 1991, followed by the division of requests between different categories of users.
COMPUTER PROGRAM TESTING

When a computer program is received from its authors, it is checked to ensure that all the information required is present, and is assigned to a programmer for "testing".

This process involves "screening" the source text of the original program with a software diagnostic toolkit to identify a first level of coding errors or omissions, then compiling it and running one or more test problems (the problem and its results are normally supplied by the author) until the tests produce the "right" answer. Any errors detected are corrected in consultation with the author, and the corrected program text, user documentation, sample job control instructions, test problem with "correct" solution, etc., are filed together as a "program package" ready for dispatch to users, in the master files on permanent disk storage.

Where a program is to be distributed "as is" (untested), it will be checked for completeness, "screened", but without making changes to the program, packaged as above and included in the master files.

The Need for Program Testing

When authors submit their programs for inclusion in the Data Bank's collection, they normally send the version they themselves are using. Why then does it need testing?

A typical reactor physics or nuclear engineering program sent out to a requester contains about 20,000 lines of program text ("source code") and was written for use on a mainframe computer. Such a program represents an investment of hundreds of thousands of dollars in development costs, and is used and updated over many years and through successive changes to the operating system and compiler under which it runs. In the course of these changes, the program may acquire "patches" to the code or special sub-routines, which may not execute correctly even on other computers of the same type.

The first aim in testing is to replace any non-standard code corresponding to the local conditions in the author's institute, and to correct other errors detected, which may not be revealed clearly by the test program, so that the program can be installed and run "correctly" on computers within the current range of the computer series for which it was originally written. Where user interest justifies the work, versions may also be prepared for other types of computers.

This work constitutes only a limited "verification" of the program, and certainly does not amount to "validation" (see below). It does however save much programming work during the initial phase of bringing the program into use. On average, ten copies of each program tested are distributed to users in participating countries; the cost of initial verification to ensure that the program will run properly is incurred only once.

THE IMPORTANCE OF PROGRAM VALIDATION

Over the last decade, "safe" programming methods and procedures have become more widely accepted, while the FORTRAN language almost universally used by programmers in nuclear technology has been much improved, with wide acceptance of FORTRAN 77 as a de facto standard. Today it would be unusual to start work on a major programming project without defining in advance the programming practices and quality control procedures to be adopted. However, very many of the most important nuclear codes were written during the years 1960-80, without benefit of such procedures. They were normally validated in predicting the behaviour of specially built experimental assemblies, and later in predicting the behaviour of working reactors. The more
important of these codes have been the subject of continuing development until the present, and have been regularly compared in “benchmark” exercises with experimental measurements and with other similar programs.

The Nuclear Science Committee’s working party on Advanced Computing (WPAC) has set up three task forces to work in this area, on:

- **Scientific Applications Software**, which will review the problems of quality assurance for existing software of the kind described above, which has been confirmed in use over many years.
- **Standards and Quality Assurance** will review and collate the diverse standards developing in Member countries in order to identify a possible consensus approach.
- **Process Control Systems**. In addition to the questions discussed above, applied in fact mainly to modelling and design software, the real-time operation of process control systems raises a number of separate issues that need to be considered in the framework of a collaboration between NEA Member countries.

**International Program Comparisons**

Colloquially called “benchmarks” by the scientists involved, these comparisons of the predictions obtained from different programs with measurements of the real phenomena being modelled are an indispensable part of the validation process. However well and “safely” a program is written so as to perform as the author planned, it remains essential to check the validity of the physical and mathematical modelling of the process it is intended to predict.

The different working parties of the Nuclear Science Committee have several such benchmark studies in progress:

- Burn-up credit for spent fuel storage and transport
- Power distribution within light-water reactor fuel assemblies
- Accuracy of radial power distribution prediction for large liquid-metal fast breeder reactors
- Sodium void reactivity reduction in fast reactors
- Comparison of codes for calculating nuclear reaction data
- 3D core transients in light-water reactors
- Experimental techniques for measuring tritium production rates.

**Program Testing Policy**

For many years, the acquisition and testing of computer programs have been guided by the number of requests received. This ensures that the content of the master files evolves in accordance with user needs, and is thus “market driven”. However, there was a leap forward in demand in 1989-91, from about 1 400 packages to 1 600 program packages a year averaged over those three years, due mainly to requests for PC versions of well-known mainframe programs. Over the coming years, the increase will be compounded by the need to provide a higher degree of validation for a small number of programs selected in consultation with the NSC.

Fortunately, and over the same period, the spread of the FORTRAN 77 language standard has brought a greater degree of compatibility between programs written for different types of computers. Sophisticated “toolkit” programs (the RXVP package is used by the Data Bank) allow codes to be
checked for “quality” as well as for strict conformity to the language standard, thus simplifying the testing process. This feature also makes it possible to screen some incoming programs to ensure that their quality is sufficient to allow distribution “as is” (untested) without excessive inconvenience to users, and this option will be used where appropriate.

Benchmarking as a method of validation is strongly dependent on user participation, which has been enthusiastic, and the success of proposals for more intensive program validation will likewise depend on the participation of scientists whose work stands to benefit from the results. With fixed staffing levels in the Data Bank, the help of key users will be essential in achieving the increase in “added value” we are aiming at: we believe it will be forthcoming.

THE VALUE OF THE COMPUTER PROGRAM SERVICE

The validity of any scientific work depends on reproducibility of the results obtained by each scientist, and effective collaboration requires comparability between the work of different groups. As we have seen, work in nuclear science is strongly dependent on computer use: \textit{comparability and reproducibility can only be maintained if each computer program and the data needed to run it are available at any given time in a single, identifiable version}. The Data Bank provides this service.

The Nuclear Science Committee is a focus for the very strong collaboration between Member countries in all aspects of their nuclear science programmes. The Data Bank, under the Committee’s supervision, is ideally placed to provide the software and data needed for their work, and to assist in the collation, analysis and distribution of the results to other scientists. The validated software and data which result are basic components of today’s nuclear technology.
SITUATION IN 1991

In 1991, the generation of electricity from nuclear power in OECD countries just exceeded 1 600 terawatt-hours for the first time, contributing 23.5 per cent of all public electricity generation; there was an increase over the previous year of just over 2 per cent.

It appears likely that over the next decade or so, this proportionate contribution of nuclear power will not be exceeded, even with the predicted increase in the absolute contribution. Installed nuclear capacity (net) rose from 261.5 GWe to 264.6 GWe during the year. The number of reactors connected to the grid was 321, while 7 units were taken out of service.

ESTIMATES OF NUCLEAR ELECTRICITY CAPACITY IN THE OECD AREA

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nuclear</td>
<td>%</td>
<td>Nuclear</td>
</tr>
<tr>
<td>Belgium</td>
<td>5.5</td>
<td>39.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Canada</td>
<td>13.5</td>
<td>13.0</td>
<td>14.0</td>
</tr>
<tr>
<td>Finland</td>
<td>2.3</td>
<td>18.4</td>
<td>2.3</td>
</tr>
<tr>
<td>France</td>
<td>55.8</td>
<td>54.1</td>
<td>56.8</td>
</tr>
<tr>
<td>Germany</td>
<td>22.4</td>
<td>19.1</td>
<td>22.4</td>
</tr>
<tr>
<td>Italy</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Japan</td>
<td>30.0</td>
<td>17.5</td>
<td>31.6</td>
</tr>
<tr>
<td>Netherlands</td>
<td>0.5</td>
<td>2.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Spain</td>
<td>7.0</td>
<td>16.1</td>
<td>7.0</td>
</tr>
<tr>
<td>Sweden</td>
<td>10.0</td>
<td>29.2</td>
<td>10.0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>3.0</td>
<td>19.4</td>
<td>3.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>11.5</td>
<td>15.5</td>
<td>11.5</td>
</tr>
<tr>
<td>United States</td>
<td>100.0</td>
<td>13.7</td>
<td>100.0</td>
</tr>
<tr>
<td>OECD Total</td>
<td>261.5</td>
<td>16.1</td>
<td>264.6</td>
</tr>
</tbody>
</table>

(a) Secretariat estimate.

STATUS OF NUCLEAR POWER PLANTS (as of 31st December 1991)

<table>
<thead>
<tr>
<th>Country</th>
<th>Connected to the grid</th>
<th>Under construction</th>
<th>Firmly committed</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>Capacity</td>
<td>Units</td>
<td>Capacity</td>
</tr>
<tr>
<td>Belgium</td>
<td>7</td>
<td>5.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Canada</td>
<td>20</td>
<td>13.7</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Finland</td>
<td>4</td>
<td>2.3</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>France</td>
<td>56</td>
<td>56.8</td>
<td>5</td>
<td>7.0</td>
</tr>
<tr>
<td>Germany</td>
<td>21</td>
<td>22.2</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Italy</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Japan (a)</td>
<td>42</td>
<td>31.7</td>
<td>11</td>
<td>10.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2</td>
<td>0.5</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Spain</td>
<td>9</td>
<td>7.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Sweden</td>
<td>12</td>
<td>10.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>5</td>
<td>3.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Turkey</td>
<td>0</td>
<td>0.0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>32</td>
<td>11.5</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>United States</td>
<td>111</td>
<td>100.0</td>
<td>2</td>
<td>2.0</td>
</tr>
<tr>
<td>OECD Total</td>
<td>321</td>
<td>264.2</td>
<td>21</td>
<td>22.3</td>
</tr>
</tbody>
</table>

(a) Gross data converted to net by the Secretariat.
CIVIL NUCLEAR LIABILITY: JOINT PROTOCOL ENTERS INTO FORCE

On 27 April 1992, international efforts to establish a comprehensive international regime of liability for nuclear damage took a step forward with the entry into force of the 1988 Joint Protocol relating to the application of the Vienna Convention and the Paris Convention.

The Paris Convention on Third Party Liability in the Field of Nuclear Energy, concluded under the auspices of the OECD/NEA in 1960, is in force for 14 western European countries. The 1963 Vienna Convention on Civil Liability for Nuclear Damage was adopted within the framework of the IAEA and currently has 17 Parties.

Both Conventions govern the liability of operators of nuclear installations for damage caused by accidents in their installations or during transport of nuclear material, and their provisions are substantially the same. Until now, however, they operated in isolation from each other, i.e. each Convention benefitted only victims within the territory of its own Parties, so that, for example, damage occurring in a Paris Convention Party, caused by an accident in a Vienna Convention Party, would not be covered by either Convention.

The Joint Protocol establishes a bridge between the two Conventions, by extending the benefit of each Convention to the Parties to the other, so that nuclear damage suffered in a Party to the Vienna Convention is eligible for the compensation guaranteed by the Paris Convention and vice versa. It also avoids both Conventions applying to the same accident.

The Joint Protocol was adopted in 1988 as the result of the combined efforts of the NEA and the IAEA. Its entry into force this year constitutes a significant extension of the scope of the existing nuclear liability regime, pending the more substantial revision of that regime presently being studied within the framework of the IAEA.

The Contracting Parties to the Joint Protocol to date are Cameroon, Chile, Egypt, Hungary and Poland (Vienna Convention Parties) and Denmark, Italy, the Netherlands, Norway and Sweden (Paris Convention Parties).

POWER GENERATION CHOICES: COSTS, RISKS AND EXTERNALITIES — AN INTERNATIONAL PERSPECTIVE

Historically, choices between different means of producing electricity have rested largely on attempting to minimise the costs (cost being taken in its broadest sense) of electricity production. In recent years, additional factors including so-called externalities have also become issues in decision-making regarding technology choices. Therefore, the OECD Nuclear Energy Agency will organise an international symposium on Power Generation Choices: Costs, Risks and Externalities — An International Perspective. This symposium, to be held in September 1993, will provide a comprehensive examination of the total costs of nuclear power and other generating technologies. The objective is to examine the state-of-the-art in economic analysis of nuclear power and other fuels and energy forms used in electricity generation, from a total cost perspective within a pragmatic decision-making context. The symposium will consider what can be quantified (e.g. environmental, health, trade, security of supply, risks related to public acceptance, etc.) and what criteria (methods, assumptions, etc.) should be used in economic comparisons. Consideration will also be given to externalities (which include environmental and health and safety issues), as well as to broad impacts such as macro-economic and strategic issues.

•49•
ELECTRICITY CASTS ITS SPELL

“Olivier Bonnard, a Swiss photographer, turns his gaze on the electric light bulb, seeing it through the eyes of an explorer and a visionary, and discovering beneath the surface of a humdrum object a lava-strewn world of yawning chasms lit by points of burning light, reflecting, perhaps, the inner torment of the daring caver, the explorer of hidden depths, which he once was. These mysterious forms clad in shot velvet and gleaming like burnished copper have been freed from their vitreous prison, turned by the eye of the photographer into an alchemist’s crucible. And now it is our turn to decipher the hidden message they hold.”


Olivier Bonnard, a Swiss national, is equally gifted in two separate modes of artistic expression. In one, as a graduate in social psychology, he deploys his talents as a writer, photographer, and video and 16 mm film-maker, areas in which he lectures at the École Cantonale d’Art in Lausanne. In the other, as a photographer, he has specialised for the past twenty years in macrophotography, investigating the world of the humble electric light bulb. His work has recently been shown in a series of Art Photothèque exhibitions sponsored by the Fondation Électricité de France in Paris (1991), Toulouse and Tarbes (1992).
NEW NEA PUBLICATIONS

OECD Nuclear Energy Data 1992

Nuclear Energy Data is the annual compilation of basic statistics on electricity generation and nuclear power in OECD countries. The reader will find quick and easy reference to the present status of and projected trends in total electricity generating capacity, nuclear generating capacity, and actual electricity production, as well as on supply and demand for nuclear fuel cycle services.

45 pages
ISBN 92-64-03680-6 / ISSN 1017 9402
£8, FF60, US$14, DM23

In-Core Instrumentation and Reactor Core Assessment

Proceedings of a specialists’ meeting, Pittsburg, USA, 1-4 October 1991

Information on the conditions in the reactor core is essential for the safe and economic operation of nuclear reactors. These proceedings review the important aspects of measurement and interpretation of reactor core parameters. Contributions from industry and research laboratories in a number of countries cover sensor technology, measurement methods and core performance evaluation.

400 pages
ISBN 92-64-03682-2
£40, FF280, US$67, DM 133

International Co-operation on Decommissioning: Achievements of the NEA Co-operative Programme 1985-1990

Decommissioning of nuclear facilities is attracting a growing interest in all countries where an increasing number of plants are reaching the end of their operational life and will have to be decommissioned in the next few years.

In response to this interest, the NEA set up in 1985 an international programme of technical cooperation between decommissioning projects in eight OECD countries. This report describes the programme and the participating projects, and reviews the results and experience achieved during the first five-year term of this international undertaking.

184 pages
ISBN 92-64-13636-3
FF240, £31.50, US$58, DM92

Radioactive Waste Management: Gas Generation and Release from Radioactive Waste Repositories


Extensive work has been carried out during the last few years to explore the significance of gas generation and release in radioactive waste repositories, and to determine to what extent the associated phenomena have to be taken into account in the planning, design and safety assessment of repositories. A recent workshop organised by the OECD Nuclear Energy Agency, in cooperation with ANDRA (France), brought together experts from many NEA Member countries to discuss issues of common concern in this field. These proceedings reproduce the papers presented at the workshop together with an extensive record of the discussions, and summarise the state of knowledge on most issues related to gas generation and release in radioactive waste repositories.

440 pages – ISBN 92-64-03691-1
£42, FF300, US$78, DM122

Proceedings of the International Seminar on Decommissioning Policies

Paris, 2-4 October 1991

Decommissioning strategies for nuclear facilities differ widely between countries. They range from immediate dismantling to dismantling after a long dormancy period or entombment. The OECD Nuclear Energy Agency (NEA) and the International Atomic Energy Agency jointly organised an international seminar to identify the causes of this variation, and to examine the key factors affecting the policy decisions of countries and utilities. This publication contains the papers presented and a record of the panel discussions held during the meeting.

400 pages – ISBN 92-64-03689-X
£45, FF320, US$82, DM130

FREE ON REQUEST

NEA Activities in 1991

Newsletter, Spring 1992. Vol. 10, No. 1


The International Hydrocoin Project - Summary Report

NEA Newsletter - Autumn 1992