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NUCLEAR ENERGY AGENCY
COMMITTEE ON NUCLEAR REGULATORY ACTIVITIES

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WORKSHOP ON ASSURING NUCLEAR SAFETY COMPETENCE INTO THE 21st CENTURY

Organised in collaboration with the Hungarian Atomic Energy Authority

Held in Budapest, Hungary, on 12-14 October 1999

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC 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 27 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

COMMITTEE ON NUCLEAR REGULATORY ACTIVITIES

The Committee on Nuclear Regulatory Activities (CNRA) of the OECD Nuclear Energy Agency (NEA) is an international committee made up primarily of senior nuclear regulators. It was set up in 1989 as a forum for the exchange of information and experience among regulatory organisations and for the review of developments which could affect regulatory requirements.

The Committee is responsible for the programme of the NEA, concerning the regulation, licensing and inspection of nuclear installations. The Committee reviews developments which could affect regulatory requirements with the objective of providing members with an understanding of the motivation for new regulatory requirements under consideration and an opportunity to offer suggestions that might improve them or avoid disparities among Member Countries. In particular, the Committee reviews current practices and operating experience.

The Committee focuses primarily on power reactors and other nuclear installations currently being built and operated. It also may consider the regulatory implications of new designs of power reactors and other types of nuclear installations.

In implementing its programme, the CNRA establishes co-operative mechanisms with NEA's Committee on the Safety of Nuclear Installations (CSNI), responsible for co-ordinating the activities of the Agency concerning the technical aspects of design, construction and operation of nuclear installations insofar as they affect the safety of such installations. It also co-operates with NEA's Committee on Radiation Protection and Public Health (CRPPH) and NEA's Radioactive Waste Management Committee (RWMC) on matters of common interest.

TABLE OF CONTENTS

SUMMARY AND CONCLUSIONS

Executive summary

A workshop took place in Budapest between 12 and 14 October 1999 to consider issues concerning assuring nuclear safety competence into 21st century. This was in response to recommendations from the Committee on Nuclear Regulatory Activities (CNRA). A number of invited papers were presented along with presentations from Member countries. Whilst there were country differences and perspectives the problems were recognised, particularly the long-term strategic nature of the issues. Action is needed **now** due to the time lag to restore competence losses. The CNRA is invited to highlight the issues to OECD and consider what actions it can take in response to the recommendations made in this report. Specific attention is drawn to:

- The need for a long-term view and planning.
- Preservation of core subjects.
- The Young Generation Network
- Encourage development of the IAEA documents on regulatory competencies.
- Knowledge capture and advancement

REPORT

1. Introduction

1.1 Purpose of workshop

In its report on new future regulatory challenges the Committee on Nuclear Regulatory Activities (CNRA) identified the human element "*as one of the most critical aspects of maintaining regulatory effectiveness, efficiency and quality of work."* There is a need to preserve among the staff collective knowledge in all relevant technical disciplines with sufficient depth to permit adequate independent assessment of safety issues.

There was consensus that:

"Quality organisations require well educated, well-trained and well motivated staff. In some countries, national R&D programmes are being reduced to such a point that forming an independent regulatory position might be in jeopardy. If a significant problem occurred over the next ten years, there might not be sufficient knowledge and capability to deal with it in a timely manner if the current trend continues."

Based on these concerns the CNRA recommended that a workshop should be organised in 1999 to consider the most efficient approach to recruiting, training and retaining safety staff, and preserving a critical mass of knowledge, both within **industry and regulatory bodies.** These are issues that are of concern not only as part of the wider nuclear industry, but also for governments in maintaining an infrastructure to assure safety into the future. It was therefore particularly important to establish the common issues between industry and the regulator.

1.2 Location of workshop and participants

The workshop was held in Budapest from 12 to 14 October 1999; it was organised in collaboration with the Hungarian Atomic Energy Authority (HAEA). There were twenty-eight participants, representing organisations in Belgium, Canada, Finland, Germany, Hungary, the Republic of Korea, Mexico, the Netherlands, Slovenia, Spain, Sweden, the United Kingdom and the United States, as well as the International Atomic Energy Agency (IAEA) and the OECD/NEA. The programme of the workshop is given in Appendix 2.

1.3 Reasons for concerns

Irrespective of current views on the future of a nuclear power programme across OECD Member countries there are safety concerns for the future. These arise from the long-term ability to preserve safety competence within the industry and the regulator, in particular because the number of enrolments in the

fields of nuclear science and engineering are decreasing rapidly in most universities and engineering schools. In addressing this issue the workshop identified three reasons why this was appropriate:

- nuclear power programmes are in place and have to be safely managed;
- nuclear power is international, and events in other countries have a world-wide impact;
- reasonable options for the future have to be kept open.

Whether there is a strong development of nuclear power into the future or it is terminated, there is still a need to maintain competence now and into the future. The nature of these competencies may change but the basic principle of safety remains. This has a further impact on the regulator in terms of the competencies required to regulate. In order to maintain publicly acceptable standards of safety, governments cannot avoid their responsibility. Their responsibility influences the energy markets and hence the industry. The situation is also strongly influenced by the political will, determination and desire to establish an independent effective and competent regulator and an education system which allows for the development of technically qualified talent into the future. Furthermore there is a need to maintain and develop appropriate safety research as this can also provide the catalyst for dynamic and attractive education programmes and co-operation between industry and education.

The nuclear industry is considered, in many countries, as mature and the nuclear safety competence is predominantly vested in the same age group. The age distribution for regulators is over 40 in most countries. In countries with active programmes this age is slightly lower, and in those in decline the situation is worse. The time is rapidly approaching when this group will be retiring, over a period of a few years (this phenomenon was described at the Workshop by the analogy of “the rabbit in the snake”). The situation is similar in the nuclear industry. Doing nothing is not an acceptable option as there is unwavering demand for a high degree of nuclear safety competence for at least one more generation even if nuclear power was terminated immediately. To address the safety implications there will be a need for:

- competence, should there be extensions to present nuclear programmes;
- maintenance of a living safety case;
- safety of operating installations;
- ensuring safe decommissioning;
- safe spent fuel and radioactive waste management.

Programmes to initiate knowledge transfer, suitable research and relevant competence renovation must be started as early as possible or it will not be possible to recover the position.

2. Review of workshop discussions and outcomes

2.1 Workshop format

The number of people attending the workshop was somewhat smaller than expected. However, this facilitated very open discussions and development of proposals. There was active participation from all experts present. The positions in each country and how the issues impacted on the necessary competencies

were established. Ultimately there was significant agreement over the principal issues and ways in which these could be addressed. The key areas identified were:

- no new nuclear plant being built in the majority of countries;
- lack of vitality in research;
- the nuclear industry is considered to be unattractive by new entrants;
- ageing workforce.

These areas will be expanded upon in this report.

2.2 Summary of presentations

The papers presented are set out in the workshop agenda and the Session Chairmen have produced a summary of the main points and common threads presented during each session. This is set out in Appendix 1.

2.2.1 Overview of position based on presentations

The status of nuclear programmes varies across countries. This leads to differences in perception of the issue. Countries still developing their nuclear programmes such as France, Japan and Korea, and, for different reasons, Central and Eastern European countries, have less difficulty with recruitment to regulatory bodies and the industry. The fact that government confidence in nuclear power is strong leads to a better perception amongst the public, which facilitates the ability to preserve competence. There are still calls for greater efficiency, which can also impact on the regulator. At the other end of the scale there are countries where nuclear programmes are coming to an end in the next few years with no prospect of extension. They have an increasing problem in maintaining competence. These positions represent the extremes of the current situation but show how different national attitudes and policies towards nuclear development will significantly influence the perspective of the problem.

Political factors play an important part, as do public perceptions and the extent of opposition from pressure groups. This impacts on perceptions of young people, though again this varies greatly from country to country.

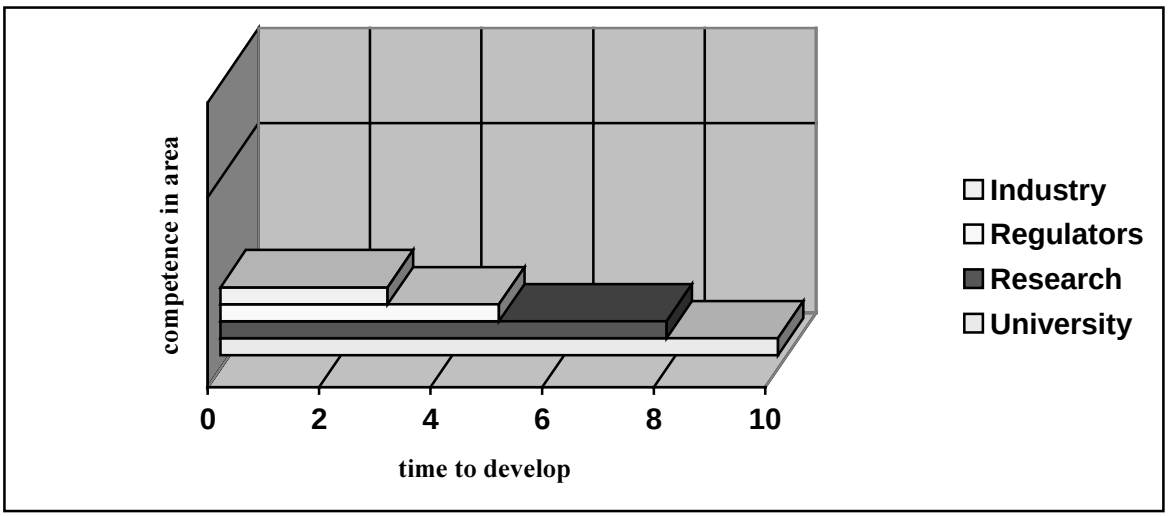
A significant political component is the desire in some areas for entry to the European Union (EU), which is giving rise to an increase in the requirement to demonstrate achievement of safety standards. In contrast, the break up of the former Soviet Union is giving rise to a different type of safety pressure. Technological support is now becoming more limited and where it is available is provided on the basis of payment from central funds rather than co-operation. This is also impacting on the availability of centralised research facilities.

Some new areas of research are opening up and research is still being maintained in areas such as material science and corrosion. However the traditional areas of research in nuclear fields such as reactor physics are declining. This is also true for several areas of safety research: large thermal-hydraulic facilities are being shut down, severe accident research programmes are reduced or cut. These factors have a significant immediate impact on universities and education and on national laboratories. If the teaching and research facilities cannot be maintained then educational programmes will gradually close. Similarly,

as people retire, the competence available to operate university-linked research facilities disappears. Both these factors have a significant impact on the ability to transfer knowledge to future generations.

The factors discussed above are intimately linked. Teaching and research is required in order to produce the right people plus training within the industry and availability of jobs. There is also the need to regenerate lost academic teaching capability. Given the ageing workforce profile there is the danger of competence being lost. Once lost there will be a substantial time lag before recovery of a specific level of competence is achieved. The time to recovery will vary. Figure 1 provides a conceptual illustration of the time to recovery arising out of the workshop deliberations. Industry has more chance of recovering quickly, as it may be able to recruit from the labour market, however in academia the time scales are much longer.

Figure 1. **Time to develop competence in particular areas**



Deregulation of the energy industry and liberalisation of the electricity market (often also called deregulation) are having a significant impact in some countries and will greatly add to the pressures to reduce manning. This may affect other countries in the future, adding to problems in human resource strategies needed to accommodate the move towards low staff numbers per power unit. It is therefore important to recognise the specifics of each country when considering the outputs from the discussions held at the workshop.

Some companies are claiming that electricity market liberalisation gives rise to better standards of safety. This is a premise that is open to challenge and will be a new challenge for the regulator in the future. Paradoxically, preliminary signs show that electricity market deregulation may require a stronger and more effective nuclear regulator (e.g., regulators need to say what is safe in terms of staffing for the long-term).

3. Trends

A range of information was presented at the workshop and even though the country differences have to be recognised, trends could still be identified.

3.1 Academic

Representatives from the nuclear education field presented information, which demonstrated a trend of undergraduate programmes declining in most countries; nuclear departments have been merged or eliminated. University teaching programmes have been broadened, masking the impact of the reduction in student numbers. The OECD/NEA Nuclear Education Study and recent American studies provide the best reference in raw data terms. As programmes close there is less research support available to the industry, which further reduces the potential for attracting students and funding. Additionally, educators are ageing and, as they retire, further pressures are placed on availability of teaching courses and research programmes. On the positive side, whilst there is an increasing lack of interest in nuclear study, there is still a good job market for numerate and technically qualified graduates in other fields. In addition a number of countries have recognised that there is a need to be proactive. In some cases, support for universities is in place to try and maintain key competencies, there are initiatives to look at human resource plans and better targeting of competence requirements.

3.2 Future power programmes

The choices for future power programmes, and indeed existing programmes, depend on the economic situation and status of available natural resources, and political considerations. There is an active lobby by anti-nuclear groups but there appears to be an increasing awareness of CO_2 issues post – Kyoto. This provides both a threat and an opportunity. Some green groups are becoming far more sophisticated and use international pressure groups to distribute the message. Regulators also need to become more sophisticated – this is a new skill –, and perhaps more aware of international interactions and international collaboration.

3.3 Privatisation

Privatisation is happening more and more as the large state-run monopolies are broken up. This trend was recognised in the CNRA report. A further effect is how this is changing the nature of the operator. Their obligations are wider and they need to be confident, convinced and competent about their responsibilities and duties (there is an important role to be played by safety culture). There is a need for them to act as intelligent customers and ensure that they have the right mix of skills needed for both today's technology and for that of the future.

The trend of open competition in the electricity supply market is increasing. This affects different countries in different ways and is again related to the status of nuclear power programmes.

3.4 New challenges

There are now new technological and intellectual challenges that are becoming attractive areas for work. The dramatic change in the nuclear weapons programmes has reinforced this trend in the concerned countries. Whilst these challenges tend to be short-term projects, they do provide a feed of new recruitment with the opportunity for knowledge transfer and refreshment of present staff not only in terms of the age profile but also in motivation and passing on of knowledge.

Life extension is one of the aspects a number of operators world-wide are looking at more and more, particularly where there is no new construction in prospect. There is a range of economic and political reasons in each country for this trend. It is causing increased effort on living safety cases and relicensing plus the requirement for research capability to examine ageing issues. These aspects will require resources into the future.

Increasing numbers of plants will move into the decommissioning phase, shifting effort onto the decommissioning activities, long-term storage, waste disposal, etc. This will require research and people to man decommissioning programmes. There will be a consequent impact on regulator and utility. This is a challenge and an opportunity to capture public support and send out positive messages if these activities can be managed properly.

A number of countries can be considered as exporters of design and expertise, however as they are not any longer designing new plants the expertise could disappear while their indirect responsibility – or, at least, their direct interest – in maintaining or improving safety in importing countries will remain. Purchasers of existing technologies may have to become self-sufficient or buy services. The distinction between exporting and importing countries is becoming blurred.

3.5 Nuclear research

Although there is concern about the decreasing level of nuclear safety research resources, there is a continuing need for safety research, for several reasons:

- there are residual concerns (although the range of uncertainties is limited); there is potential for further improvement;
- one needs to be able to address emerging safety issues, and to anticipate problems of potential significance;
- safety research contributes to establishing the independence of the regulator;
- safety research attracts the most brilliant students and experts, and so contributes strongly to the maintenance of nuclear safety competence.

3.6 Co-operation

Increasing international co-operation and globalisation at all levels is occurring. There is international liaison by plant operators [Institute of Nuclear Power Operations (INPO), World Association of Nuclear Operators (WANO)]. Regulators are co-operating more and more. Problems are global but mechanisms for solutions are probably in place.

3.7 Use of the legal system

There is an increasing trend to look to the courts to settle issues. This is happening at national levels and between the regulator and the industry. Technical experts are being challenged more and more and there is an increasing distrust of technical experts. This is leading to the need for a range of new softer management skills for the regulator and the industry. This is exacerbated by the decreasing numbers of technical experts available.

3.8 Economics

Increased liberalisation and pressure to cut costs are giving rise to higher efficiencies in plants such as extended operating cycles or reduced outage times. This could change the nature of the regulatory role.

3.9 Wider challenges

Economics is not just the only challenge – increasingly there is concern over proliferation of nuclear weapons (this could influence the future of reprocessing), over significant climate changes due to the burning of fossil fuels, and over sustainable development constraints. Security of supply is another important consideration as far as energy is concerned.

4. Short-term and long-term challenges

Some short-term and long-term challenges emerged from the discussions. Some of them have been examined further in relation to the good practice that was presented and summarised as recommendations. For completeness the challenges identified are:

- Adapt to the current trends.
- To find the human potential to deal with current safety case requirements and draw together the useful historical information.
- How to tap into the experience of staff before and after their retirement – retention of knowledge.
- Transfer of knowledge between generations.
- Document the design-related information that is available and the reasoning that underpins it.
- Establish a methodology to institute a corporate memory. Bring experts together to capture knowledge. Take full advantage of the possibilities of on-the-job training.
- Debriefing of people who have the knowledge e.g. core design.
- Try to change the attitudes and climate amongst the young and rest of population. Project a more positive and more dynamic image of the nuclear power industry: make it a "winner" again.
- Identify the core of nuclear expertise that is actually required – if you were to stop nuclear power now, what would render us unsafe if lost – (the view was that this was not just reactor physics, although it was recognised that few skills are solely applicable to nuclear).
- How to use new and important challenges that are emerging as magnet for new work and allow availability of staff for knowledge transfer. These new, important and motivating challenges – including the development of new concepts and designs – are also the best way to attract the best and brightest young students and experts.
- How to be able to provide the infrastructure to support re-creation of the technology.
- How to anticipate the needs of the industry 10 to 20 years ahead. Contrary to training, education requires long lead times. If the educational system is lost, it takes a long time to rebuild. In some cases, decisions regarding the needs and capabilities of the year 2010 need to be taken now.

- How to preserve the educators and instructors and provide for their own succession.

- Centres of excellence, to maintain and develop expertise and train newcomers to the field, e.g., to provide high level postgraduate training in reactor physics and attract top class students; this concept has been advocated in different contexts, including industrial ones – however much research is needed to keep the trainers going and which steps are needed to regenerate the trainers?

5. Recommendations

5.*1* *Overview*

As discussed earlier, common threads and themes emerged along with some evidence of measures being taken. It was clear that there were aspects that were within the remit of people who attended the workshop. They had identified the issues and had the opportunity to develop links to other groups or within their own country to try and promote good practice. Bodies such as the IAEA already had mechanisms that could also be used. Furthermore, there was a need for wider recognition of the problems and a forum to support the initiatives identified. It is in this area where OECD/NEA have an influence. There are therefore aspects, which the CNRA can develop and promote plus lending their support. In this way there is the opportunity to influence the key groups within each country.

The general recommendations have therefore been broken down into groups to reflect this view. The first group concerns recommendations that workshop participants may be able to take forward or influence CNRA representatives. The second group is targeted more at the CNRA as a body. The aspect that needs specific consideration by the CNRA is set out in bold.

5.2 Workshop attendees

What is it that the workshop can do, in terms of recommendations to the CNRA, to address the challenges?

Several presentations outline work concerning competence frameworks (Canada, Finland and IAEA): these can apply to those within industry and to regulators. **This work needs to be encouraged and drawn together**.

Currently there is a range of international collaboration activities. Better use could be made of exchanges and pooling of staff, fellowships support for joint facilities, pooling of facilities or creation of joint projects, etc. International operator and regulator organisations could investigate and promote pooling of facilities. The Committee on the Safety of Nuclear Installations (CSNI) has initiated programmes to preserve key safety research facilities, programmes and capabilities through international collaboration.

There is also a range of national collaboration activities, e.g., co-operation between universities to provide optimal undergraduate and postgraduate programmes. In Belgium, universities have created a common postgraduate degree in nuclear engineering by combining their education activities into a national network. It has been proposed to extend this scheme to a broader European context.

Regulators need to involve themselves more in the ways in which training is being provided – from university level right the way through to employment. They also need to examine how industry actually does this, and how plans are made for the future (up to five or ten years: regulators have to get involved in the totality of the “snake”). There is a role for regulators in being proactive. Regulators should

also provide for their own continued training. Country examples are available where human resource plans have been developed. **The methodology and approaches can be shared irrespective of the often fundamental problem of availability of staff**.

Operators have a responsibility for the "front end" costs of the training of their own staff, and to some extent of their contractors also. Development of fellowships and co-operation in centres of excellence should be encouraged. **It should not be forgotten, however, that industry focuses on the short-term; strategic long-term considerations are the task of governments.**

The responsibility for ensuring competence rests with different bodies. As part of this there is also the responsibility for the provision of adequate training facilities. In some countries, it is the regulator, whereas in others it is the government. This responsibility needs to be understood and clarified. In any case, universities need support from industry, technical support organisations and regulatory bodies (governments), in the form of lecturers, research possibilities, financial assistance, temporary employment, recruitment.

The Swedish Centre of Nuclear Technology is an initiative which found support. It operates with limited funding and manning but is an initiative that could be expanded. It has some features, which parallel the BNFL industry based initiative to maintain radiochemistry competence.

The European Nuclear Society (ENS) Young Generation Network (YGN), in a number of European countries, is an established and an important and promising network. The paper presented by the YGN at the workshop set out cogent arguments and suggestions. This paper should be examined and a mechanism established to try and utilise the talent available within the network members. They should also be asked for ideas and suggestions for their recommendations for this topic. National nuclear societies should organise active and substantial programmes for the YGN, give them specific missions and responsibilities.

Young employees should be given responsibilities as soon as possible, in order to speed up the build-up of experience, to make work more interesting and meaningful, and to increase motivation and work satisfaction.

There is co-operation between centres of expertise. Modern communications technology could enhance these linkages and perhaps enable new areas of technology transfer to be established. Use of computer-based conferencing and Internet facilities to utilise some of the sophisticated computer based equipment within the nuclear industry could help to create interest. This is an emerging area not fully covered at this workshop but could be an issue for the workshop participants to identify with a view to a specific more detailed workshop.

There is a need to increase co-operation through bilateral collaborations. The Paks NPP maintenance training facilities are unique and appear very sophisticated. There is an opportunity to establish a centre of expertise in VVER technology which could be utilised extensively in the field of training and skill transfer. The facilities could be used commercially.

The participants from the educational field had very positive feedback concerning the Frédéric Joliot/Otto Hahn Summer School in Reactor Physics (held alternatively at Cadarache, France and Karlsruhe, Germany). There is scope for this to be extended and adapted.

One of the most challenging issues is how to reach schools and young people. Attracting young students to nuclear science and technology should start before they choose an education or career path. Programmes are in place in some countries; they need to be investigated further. **This is one area that the Young Generation Network could help significantly**.

There are a number of people and groups throughout the world who have significant knowledge. Furthermore modern technology facilitates easy contact. There is scope for the development of mentoring schemes across countries. Systems operate within countries and within some companies. There is scope for extension of this principle. **A framework for developing such an approach needs to be established**.

5.3 Recommendations to the CNRA

General recommendations for the CNRA; areas which members can influence but which may be outside their direct control

A number of the areas, which have been identified touch on national policies. Special pleading for the nuclear industry and its problems is not the objective. However there has to be recognition of the issues and willingness for them to be taken seriously. It is in this area that the CNRA can help. The specific areas relevant to the CNRA are set out below.

A long-term strategic view must be taken. In view of the long-term nature of nuclear safety, programmes to ensure the supply of staff with the necessary competencies must look ten years ahead and transcend short-term economic views. Investment in people has similar time scale considerations to those of facility lifetimes. The issue of future training needs to be taken seriously and has to be addressed, as it will not go away. This recommendation is applicable to regulators and utilities.

International collaboration can help but programmes need to be developed and supported.

There is no substitute for government to support the safety aspects, in particular some aspects of safety research. If nuclear competence is to be kept alive then there have to be areas of research and support for research, otherwise it is not possible to maintain facilities and a supply of staff with specialist nuclear physics and engineering skills into the future. Once gone it will not be replaced. **Those disciplines peculiar to the nuclear industry need to be identified and kept alive**.

Regulators need to consider the issues of staff resourcing, training and behaviour as part of their regulatory function. Competence is not just a matter of knowledge but also behaviour.

Volume and quality of resources are important, but knowledge is of no use unless available in the right place at the right time and exercised in the right way.

Interchange of staff between regulatory bodies is recommended. Peer reviews of regulatory bodies are encouraged.

Job task analysis to draw up competence profiles now is needed. From this, a competence gap analysis both for the present and into the future should be undertaken with the commitment to review regularly.

A systematic approach to capturing knowledge is needed. The systems introduced in the USA (videotaped interviews, etc.) for capturing knowledge from the decline of the nuclear weapons programmes at the end of the cold war is a useful model which could be developed.

Use needs to be made of new technological opportunities to appeal to young engineers – example of spin-off from weapons programme in the USA. This is a way of preserving the classical technologies and preserve access to a broader community of young people.

Identify a core of subjects and "ring fence" them to ensure they are preserved. There is still a need for updating and incorporating old codes and methods into new technologies and computer science.

Develop a network of mentors and co-ordinate with the Young Generation Network and beyond. Give the YGN information on appropriate mentors in each specialist field as a way of starting to develop such a network.

Work has been done by IAEA on competencies for regulators. Other countries have developed their own profiles which will help to update the IAEA documents. **This work needs to be sponsored and promulgated amongst Member countries. As a matter of priority**.

6. Specification of further work on assuring future nuclear safety competence

6.1 Introduction

The workshop reviewed the issues that had been identified and provided information on work in hand along with some recommendations and possible ways ahead, summarised above. The attendees could take up some of the work identified but a more co-ordinated approach from a recognised international body is preferable in order that the recommendations can be developed into specific actions. To assist in developing a co-ordinated approach, the workshop output has been re-examined to draw out the key issues into a specification of further work. This specification is more targeted and aimed at being developed into a programme of work with actions.

6.2 Competence framework

One of the fundamental issues is to identifying the competencies you actually require. This provides a baseline for assessment of current adequacy and investigation of future needs. The IAEA undertook some work a few years ago and developed a competence framework for regulators. Whilst this was aimed at establishing a baseline of good practice it represents a sound starting point. This work is due to be updated and effort is required. The Atomic Energy Control Board (AECB) in Canada, and Finnish Centre for Radiation and Nuclear Safety (STUK), VTT and TVO in Finland, have also done work in this field and developed a framework for their organisation.

Actions

1. Undertake an examination of the competence frameworks developed and published by IAEA, AECB and Finnish organisations.

2. Examine other recent international use of competence frameworks to assist in future development of the IAEA baseline documents.

3. Initiate a review of Member country experience with competence frameworks to establish whether a revised IAEA document represents current best practice.

4. Investigate the feasibility of carrying out job and task analyses for regulators and operators to provide some generic competence profiles.

5. Establish a strategy for updating and developing the competence framework.

6. Based on the revised competence framework identify the core competencies required currently.

7. Identify the core training needs and availability of training facilities with the aim of identifying any gaps.

8. Identify the core nuclear competence requirements and investigate approaches to preserving the competence.

6.3 Encourage co-operation

Several presenters mentioned the need for co-operation across education and research facilities to support for interchange of staff and pooling of resources. This is a very wide topic, which all will support but is difficult to translate into defined actions. The key task is to clarify a few defined areas for co-operation and identify future actions.

Actions

1. Establish the extent of co-operation schemes in use within Member countries.

2. Examine graduate and postgraduate training arrangements that support the core competencies and identify areas suitable for further development of co-operation programmes.

3. Examine the Swedish Centre for Nuclear Technology and the British Nuclear Fuels (BNFL) initiative to support radiochemistry and identify the key features.

4. Identify methods whereby either information on the approaches could be transferred or further centres established either on a national or international basis.

5. Examine the possibility of more extensive use of training facilities such as those at Paks to establish centres of excellence, which are accessible within a region.

6.4 Young Generation Network

The ENS Young Generation Network is an active organisation who is keen to provide assistance. As they already have a network established they could be used to develop contacts further. Further use of such a network will help to underpin actions in other areas such as encourage co-operation.

Actions

1. Establish a forum for improved contact with the Young Generation Network.

2. Utilise the Young Generation Network to develop an action plan for effective communication with schools and universities concerning science and technology.

3. Review the Young Generation Network paper presented at the workshop and identify the key areas in which they could provide assistance.

6.5 Mentoring

Nuclear expertise is ageing and there is a need pass on knowledge. Modern communication techniques can assist. In particular the growth of world-wide web and e-mail has enabled contacts to be maintained across countries. There is scope for utilising this technology to provide for dissemination of knowledge. The key task is to develop an approach.

Actions

1. Develop the specification and requirements for a mentoring scheme for young engineers.

2. Examine methods of using modern communication techniques.

3. Establish likely organisations that would facilitate and support such an approach.

4. Establish a small group of people prepared to help in a pilot exercise.

6.6 Need for a strategic view

The workshop identified the clear need for a long-term strategic view to be taken. The difficulty with any actions is identifying the group who would be responsible. The CNRA can provide significant influence and through NEA provide a lobby group. The individual regulators can push the need for such a long-term approach within their own organisations and those they regulate.

Actions

1. The CNRA to commission a more detailed study to pull together information from recent studies. The objective being to establish the elements of a long-term strategic plan which could be utilised by members.

2. Use the plan developed above as a tool to provide influence internationally.

3. Identify any additional short-term actions based on the strategic plan.

APPENDIX 1

MEMBERS OF THE ORGANISING COMMITTEE AND SESSION CHAIRMEN

Organising Committee:

Mr. Steve Griffiths (HSE, UK) * (Chairman) (General Chairman of the workshop)

Dr. Thomas H. Isaacs (LLNL, USA) *

Dr. Hartmut Klonk (BfS, Germany)

Dr. Klaus Kollath (GRS, Germany)

Mr. Géza Macsuga (HAEA, Hungary) *

Dr. Lasse Reiman (STUK, Finland)

Mr. Manuel Rodriguez (CSN, Spain) *

Mr. Jacques Royen (OECD/NEA) * (Secretary)

Session Chairmen:

Mr. Jim Furness (HSE, UK)

Mr. Steve Griffiths (HSE, UK)

Dr. Thomas H. Isaacs (LLNL, USA)

Prof. Zoltán Szatmáry (BME, Hungary)

Dr. Lajos Vöröss (HAEA, Hungary)

* Present at the workshop

APPENDIX 2

PROGRAMME

Tuesday 12 0ctober 1999

08.30 - 09.30 REGISTRATION

09.30 -10.00 WELCOME
L. Vöröss, Deputy Director General, HAEA
J.S. Griffiths, General Chairman of the workshop
J. Royen, Deputy Head NSD, OECD/NEA

10.00 - 17.30 INTRODUCTORY SESSION: INVITED PAPERS
Chairman: Dr. L. Vöröss (Hungary)

10.00 - 10.30 Background of the workshop, Purpose and Objectives
J.S. Griffiths, General Chairman

10.30 - 11.00 BREAK

11.00 - 11.30 Nuclear Regulatory Challenges
J. Furness (Deputy Chief Inspector, Health & Safety Executive, Nuclear Installations Inspectorate, UK)

11.30 - 12.00 Review of NEA Survey on Education and Training
T.H. Isaacs (Director, Office of Policy, Planning and Special Studies, Lawrence Livermore National Laboratory, USA)

12.00 - 12.30 Nuclear Engineering Education in the United States
G.J. Brown (University of Massachusetts-Lowell, USA)

12.30 - 14.00 LUNCH

14.00 - 14.30 Partnership for Success: Solving the Problems Together
S. Ion (Director, Technology and Operations, British Nuclear Fuels Limited, UK)

14.30 - 15.00 The Nuclear Industry and the Young Generation
A. Hanti (ENS Young Generation Network)

15.00 - 15.30 Managing Nuclear Safety Research Facilities and Capabilities in a Changing Nuclear Industry: the Contribution of OECD/NEA
J. Royen (Deputy Head, OECD/NEA Nuclear Safety Division)

Tuesday 12 October 1999 (Cont'd)

15.30 - 16.00 BREAK

16.00 - 16.30 International Organisations Assure Nuclear Safety Competence
A. Alonso Santos (Commissioner, Consejo de Seguridad Nuclear, Spain)

16.30 - 17.30 Panel and General Discussion: ***How Serious is the Challenge of Assuring Nuclear Safety Competence into the 21st Century?***
Panel Members' views
Reactions and Questions from the Participants

19.30 - Dinner hosted by HAEA

Wednesday 13 October 1999

08.30 - 11.30 Session A: HOW TO INCORPORATE NEW SAFETY CAPABILITIES THROUGH EDUCATION AND TRAINING
Chairman: Prof. Z. Szatmáry (Hungary)

08.30 - 09.00 Training at the Master's Degree Level in Physics and Technology of Nuclear Reactors in the UK
D. R. Weaver (University of Birmingham, UK)

09.00 - 09.30 The Postgraduate Education in Nuclear Engineering: Towards a European Degree
M. Giot (Université Catholique de Louvain, Belgium)

09.30 - 10.00 Graduate Nuclear Engineering Programs Motivate Educational and Research Activities
B. Mavko (University of Ljubljana, Slovenia)

10.00 - 10.30 BREAK

10.30 - 11.00 Dissemination of Opportunities in Nuclear Science and Technology in Mexico
G. S. Alcocer Gómez (Comisión Nacional de Seguridad Nuclear y Salvaguardias, Mexico)

11.00 - 11.30 The Role of the International Atomic Energy Agency in Maintaining Nuclear Safety Competence
I. Aro and T. Mazour (Department of Nuclear Safety, International Atomic Energy Agency)

11.30 - 17.30 Session B: HOW TO MAINTAIN AND CONTINUOUSLY DEVELOP EXISTING SAFETY CAPABILITIES
Chairman: Mr. J. Furness (UK)

11.30 - 12.00 Nuclear Energy Related Research in Universities: Achieving the Intellectual and Funding Framework
A.T. Goddard (Imperial College, UK)

12.00 - 12.30 Challenge and Endeavor for Nuclear Safety Competence in Korea: for Now and into the 21st Century
M. Kim, J.-I. Lee and Y.-H. Hah (Korea Institute of Nuclear Safety) and J.-H. Kim (Ministry of Science and Technology, Korea)

12.30 - 14.00 LUNCH

Wednesday 13 October 1999 (Cont'd)

14.00 - 14.30 Ways to Maintain Nuclear Safety Competence in Finland
T. Vanttola and L. Mattila (VTT Energy, Finland), and L. Reiman (STUK, Finland)

14.30 - 15.00 Maintaining Staff Competence - A NPP Operator Viewpoint
E. Patrakka (TVO, Finland)

15.00 - 15.30 Assuring Nuclear Safety Competence into the 21st Century - A Swedish Perspective
G. Löwenhielm and G. Svensson (Swedish Nuclear Power Inspectorate/SKI, Sweden) and I. Tirén (Consultant)

15.30 - 16.00 BREAK

16.00 - 16.30 Maintaining the Nuclear Safety Competence of AECB Staff
A. Omar, N. Bélisle and I. Grant (Atomic Energy Control Board, Canada)

16.30 - 17.00 Training System Enhancement for Nuclear Safety at Paks NPP
I. Kiss (Paks Nuclear Power Plant, Hungary)

17.00 - 17.30 Experience with Generational Changes and Enhancement of Competence at the OECD Halden Reactor Project
C. Vitanza (Manager, OECD Halden Reactor Project) (paper to be presented by L. Moen)

17.30 - 18.00 Assuring Nuclear Safety Competence in the Netherlands
R.J. van Santen (Head, Nuclear Safety Department, The Netherlands)

Thursday 14 October 1999

09.00 - 12.30 **Session C: HOW TO ESTABLISH NUCLEAR SAFETY CAPABILITIES TO MEET FUTURE CHALLENGES**
Chairman: Dr. T.H. Isaacs (USA)

09.00 - 09.15 Main Conclusions of a Seminar on Managing Technical Resources in a Changing Nuclear Industry held in London on 29 September 1999
P. D. Storey (Health & Safety Executive, Nuclear Safety Directorate, UK) (paper to be presented by J.S. Griffiths)

09.15 - 10.15 Current Positions in Member Countries on Competence Profiles at Present and Requirements for the Future: Review of Questionnaire Responses
J.S. Griffiths (HSE, UK) and G. Macsuga (HAEA, Hungary)

10.15 - 10.45 Feedback on Positions from Countries

10.45 - 11.15 BREAK

11.15 - 12.30 **General Discussion on *How to Establish Nuclear Safety Capabilities to Meet Future Industry and Regulatory Challenges***
Keynote Address to be presented by *T.H. Isaacs*
Further Questions Raised by *Organising Committee Members and the Participants*

12.30 - 14.00 LUNCH

14.00 - 16.00 **Session D: REVIEW OF CONCLUSIONS AND RECOMMENDATIONS OF THE WORKSHOP**
Chairman: Mr. J.S. Griffiths (UK)

14.00 - 14.30 Session Chairmen Summaries

14.30 - 16.00 General Discussion of the Conclusions and Recommendations of the workshop

Friday 15 October 1999

09.00 - 17.00 Final Meeting of the Organising Committee and the Session Chairmen; preparation of Summary and Conclusions for the Committee on Nuclear Regulatory Activities (CNRA)

APPENDIX 3

Highlights of the Introductory Session: Invited Papers (Chairman: Dr. L. Vöröss)

Competence is not only a matter of knowledge but also of behaviour at the level of individual and organisation. The trends towards deregulation and privatisation of the energy markets raise special constraints for the nuclear industry and regulators which complicate previous relationships between the parties. Due to the lack of construction of new plants and the ageing of those which exist, the numbers of staff having an understanding of safety cases and the processes used to license nuclear plants are declining.

The comprehensive survey carried out among European Union (EU) countries and its analysis of education has revealed a general trend of ageing facilities and reduction in number of research reactors, education facilities and research laboratories as well as academic staff for future training. Changes in the skills needed for nuclear jobs can be observed: there is increasing demand for jobs like waste management and disposal, dismantling of nuclear facilities, decontamination, ageing processes. However, recruitment of talented students even to these fields is difficult.

A similar survey carried out in the USA led to the same conclusion.

Nuclear engineering education has shown a marked decline in the past decade in spite of the fact that the job market has been strong. Some innovative actions from the educational organisations have been introduced ranging from advertising, the provision of research funding and summer schools to improve recruitment. In Finland stronger governmental support provided to the Nuclear Energy Research Initiative programme has been reported.

The British industry has recognised the importance of the issue of maintaining competence and has become more proactive in its recruiting processes: visitor centres and coach trips around its sites as well as sponsoring both students and nuclear research at universities, and collaboration with other institutions in the international research areas can be mentioned as examples. An urgent investment in nuclear education, training and research is needed.

A promising initiative of the European Nuclear Society (ENS) is the establishment of the Young Generation Network aiming at involvement of young scientists and engineers into advertising the nuclear technology among the young. Improved public relations, education programmes and support for know-how transfer between generations seem to be the most effective tools to improve the image of nuclear power among the young.

The international organisations like the IAEA and OECD/NEA play significant roles in the exchange of information, which is an essential part of maintaining competencies amongst those involved in the nuclear industry. The harmonisation of criteria, methodologies, codes, standards and practices for the whole life cycle of the nuclear facilities helps solve problems in ensuring a consistent response to the challenges of the privatised and deregulated environment. Because the funding levels of national governments safety research programmes have been reduced over recent years, international efforts are necessary to keep alive those research facilities, which are available for co-ordinated research programmes in safety significant areas like severe accidents, human behaviour and ageing.

APPENDIX 4

Highlights of Session A: How to Incorporate New Safety Capabilities Through Education and Training (Chairman: Prof. Z. Szatmáry)

The interest of the young generation for nuclear subjects is definitely less than it was decades ago. This tendency corresponds to the general situation of nuclear power all over the world. However, there are differences between countries.

Symptoms of this general tendency are decreasing number of students, problems of funding, many universities closing courses in the nuclear field, etc. These are especially apparent in those countries which developed large nuclear programmes in the past (e.g., UK, USA) but where no new power plants are on order. The situation is different in countries where smaller scale nuclear programmes are going on (e.g., Slovenia): a roughly constant or slightly increasing number of students learn nuclear technology. Typical figures are: five to ten students per year which is normal for a small country (like Slovenia or other countries in Central Europe) but is considered as small for larger ones (like the UK).

Many efforts have been made to manage this situation such as partnership with the industry (UK), integration of universities into a network for assuring excellence in all fields (Belgium), organising large scale festivals for attracting young students (Mexico), etc.

International organisations like the IAEA play a significant role in maintaining competence in nuclear safety. They regularly organise schools, training courses both for professionals and newcomers (operators, researchers, regulators, etc.). It is done on a systematic basis in order to cover all fields of interest. Other activities like preparation of SAT (Systematic Approach to Training) documents, safety guides, etc. as well as OSART and ASSET missions have the same objectives.

The eventual loss of competence will have negative effects not only within the country where this happens. Most countries using nuclear technologies have imported them from those few countries which developed them (USA, Canada, France, Germany, Sweden, Russia). In this sense, the former group of countries depends on the vendors. If the latter lose competence in nuclear safety matters, this can have negative effects in the countries which imported their technologies.

APPENDIX 5

Highlights of Session B: How to Maintain and Continually Develop Existing Safety Capabilities (Chairman: Mr. B. J. Furness)

The main points arising from the papers presented in Session B of the workshop revolved around the need to provide a systematic approach to training "SAT". Many speakers agreed that the first step in this is to establish the required competency profiles for each post, considering not only present day needs but also how the required competencies might change into the future.

Having listed the required competencies, there was general agreement as to the importance of identifying the core of unique nuclear competencies which must be preserved i.e., those disciplines which do not form part of traditional engineering, physics or chemistry university courses, which it is assumed will survive without special support from the nuclear industry.

Speakers referred to the need to establish proper succession planning, having regard to the fact that in most countries, the bulk of those employed are in the 45-55 year age band. The exception to this was in Korea where the average age of those employed is around 40.

There was considerable discussion on ways of attracting entrants to the nuclear industry to meet succession needs; the use of summer and part-time jobs, allocating students interesting projects and ensuring that there was adequate job satisfaction were all mentioned. It was acknowledged that recruitment to what is perceived to be an ageing industry with little future development will be difficult, especially in the face of competition from other hi-tech industries e.g., IT.

Both for existing workers and for new entrants, training needs must be established by comparing required competencies against those already held by the individuals concerned. This process was termed a "training needs analysis". The next stage is to amalgamate individual training needs to establish programmes of site based, regional, country or country grouping training courses, exchanges, attachments, opportunities for mentoring or for distance learning etc. The role in transfer of knowledge, of co-operation with equipment vendors was mentioned, as was the value of international training courses and in particular the Frédéric Joliot/Otto Hahn summer schools. International research programmes were also discussed as a means of maintaining competence in specialist areas.

In all of this, the need to give particular support to training in the areas where the required competencies are unique to the nuclear industry was emphasised. Examples given were core neutronics, safeguards and radiation protection.

Finally, the workshop emphasised the point that all of the above good practices are not only matters for those who operate nuclear power plants. They are of equal importance to regulators, designers, vendors, and consultants involved in the nuclear industry.

APPENDIX 6

Highlights of Session C: How to Establish Nuclear Safety Capabilities to Meet Future Challenges (Chairman: Dr. T. Isaacs)

The main points of Session C focused on the status of technical resources potentially available in the future for assuring safety competence. Reviews were presented of a recent seminar on managing technical resources in a changing nuclear industry and of a recent questionnaire on country positions regarding competencies. Several points emerged.

There are a number of both threats and opportunities in managing technical resources that are receiving increasing attention as the nuclear community looks to assure nuclear safety competence in a future that will differ greatly from the past and produce some unanticipated surprises.

Among the threats, which are seen as varying widely among Member countries, are:

- Downsizing – as the nuclear future in a number of countries appears stagnant.
- Ageing – as the workforce approached retirement without an appropriate new motivated, capable set of replacements.
- Deregulation – will focus the industry ever more on short-term, economic decision-making.
- Business Cycles – which in a fragile industry may impel decisions that are not in a longer term best interest.
- Student interest – which as all sessions noted, has been decreasing in a majority of countries.
- Lack of R&D funding – which is seen as an important driver in attracting and keeping the best students and faculty, in providing ever better results in assuring safety as the landscape changes (e.g., older plants, D&D, waste management), and in providing an infrastructure and new personnel capable of handling safety issues both within the implementor and the regulator
- Globalisation – which makes it more diffuse to determine who is responsible.

At the same time, a number of opportunities emerge:

- Grants, scholarships, and a renewed infusion of R&D funds in a select number of countries.
- An increased awareness of the potential for manpower and expertise shortages, leading to several activities such as this workshop.

- Signs in certain countries of a job market, which may be just turning to a positive one for recent graduates with nuclear expertise.

- The creation of the Young Generation Network (YGN) and the understanding that there is a segment of the young generation that sees a future, important role for nuclear.

- There was also a sense of importance communicated regarding a need for institutions to provide continuity in knowledge and expertise.

- Recognition that governments need to be made aware of potential impending difficulties and the need to take prompt action.

- The recognition of the need for continuing education to keep employees effective in their careers and jobs.

- The importance of investigating programme clustering; that is combining resources and talents at a single or small number of locations to maximise attractiveness and expertise in a diminished market.