

ASSURING FUTURE NUCLEAR SAFETY COMPETENCIES

Specific Actions

**NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION
AND DEVELOPMENT**

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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FOREWORD

Maintaining nuclear safety competencies in nuclear regulatory authorities and the nuclear industry will be one of the most critical challenges to effective regulation of nuclear power in the coming decades. The challenge arises partly from the age profile of staff in the regulatory bodies, which could result in the loss of much of the present nuclear safety knowledge base due to retirements over the next decade or so, and partly from a decline in the numbers of students graduating from courses in nuclear science and engineering and becoming available for recruitment to fill the vacancies left by retirements.

Whatever the future of nuclear generation programmes, i.e. regardless of whether new nuclear power plants are built in Member countries, there will be an ongoing requirement for several decades in the regulatory bodies and the industry to recruit qualified staff to fill the vacancies left by retirements and to preserve the present knowledge base.

In 1999 the NEA Committee on Nuclear Regulatory Activities (CNRA) organised a workshop on “Assuring Nuclear Safety Competence into the 21st Century”. The purpose of the workshop was to consider the most efficient approach to recruiting, training and retaining safety staff, and preserving a critical mass of knowledge, both within industry and the regulatory bodies. As a result of the workshop, at the end of 1999 the Committee set up a task group to identify specific actions for assuring future nuclear safety competence.

The task group, chaired by Dr. G. Löwenhielm (SKI, Sweden), met twice in 2000 and once at the beginning of 2001. Prof. J.L. Head (UK), Facilitator of the group, wrote the attached report, which was discussed and endorsed by the full task group.

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SUMMARY

The Committee on Nuclear Regulatory Activities (CNRA) of the OECD/NEA identified the maintenance of nuclear safety competencies in the regulatory authorities as one of the most critical challenges to effective regulation of the nuclear power industry in Member countries in the coming decades. The challenge arises partly from the age profile of staff in the regulatory bodies, which could result in the loss of much of the present nuclear safety knowledge base due to retirements, and partly to a decline in the numbers of students graduating from courses in nuclear science and engineering and becoming available for recruitment to fill the vacancies left by retirements. In many Member countries, the age profile of staff in the nuclear power industry is similar to that in the regulatory authority. The industry will therefore be competing with the regulatory authority to recruit graduates, adding to the challenge.

The CNRA resolved that a workshop should be held to identify ways of recruiting, educating, training and retaining staff, so to preserve an adequate level of staffing and an adequate nuclear safety knowledge base in both the regulatory authorities and the industry. The workshop was held in Budapest in October 1999 and, in its report, made a number of recommendations for consideration by the CNRA. In particular, the report stressed the need for the development of a long-term strategy to address the challenge and, above all, the need for urgent action. As the first phase of its response to those recommendations, the CNRA set up a task group to bring forward specific practical proposals to implement the recommendations. In this report, the task group makes a number of recommendations which take account of relevant work already in progress and which, if implemented, will constitute a long-term strategy to address the challenge.

This report reviews previous relevant work, in particular the Budapest workshop and earlier studies aimed at quantifying the problem. These include a study carried out by an Expert Group set up under the auspices of the Committee for Technical and Economic Studies on Nuclear Energy Development and Fuel Cycle (NDC) of the OECD/NEA and a study carried out by the US Nuclear Engineering Department Heads Organisation (NEDHO). The

recommendations of those earlier studies are summarised. The report then reviews the wide range of initiatives already in place in Member countries in response to those earlier studies and considered by the task group to represent best practice. Many of these were the subject of papers presented and discussed at the Budapest workshop.

The report then addresses the recommendations from the Budapest workshop and formulates specific practical proposals to the CNRA to implement those recommendations, taking account of the examples of best practice described at the Budapest workshop or otherwise brought to the attention of the task group. Finally, the report reviews the recommendations from the earlier studies and concludes that task group's proposals adequately address those recommendations. The task group's proposals are summarised below:

1. The CNRA should act now because of the time lag to restore lost competencies.
2. The task group recommends that the CNRA should appoint, from its own membership and/or other recognised experts, a small group to develop a long-term strategic plan to take forward the task group's recommendations and any other issues related to the assurance of future nuclear safety competencies, to monitor specific national and international activities in this area and to keep the CNRA informed of progress. It is further recommended that workshops similar to that held in Budapest in 1999 are held at regular intervals, in order to provide a mechanism for monitoring new developments and emerging issues.
3. It is recommended that the CNRA encourages governments or government agencies to take the lead in the immediate designation or setting up of national committees comprising regulators, operators and educators, to ensure, as far as is practicable, that essential education and training facilities are identified and action taken to assure their ongoing viability.
4. The IAEA generic competency framework for regulatory bodies is commended to the CNRA as a starting point for the development of competency frameworks for national nuclear regulatory bodies.

5. The task group recommends that the CNRA should encourage the development of a generic competency framework for NPP operators, to be used by operators as a starting point for the development of competency frameworks appropriate to their own circumstances.
6. The task group recommends that, through the national regulatory bodies, the examples of best practice in national and international co-operation (described in Chapter 5) should be brought to the attention of the national committees (proposed in paragraph 6.1.5) with a recommendation that they consider whether their national education and training requirements might best be met by adopting one or more of the examples of national and/or international co-operation.
7. It is recommended that the national committees (proposed in paragraph 6.1.5) should include representatives of the YGN or similar organisations and that the committees are invited to do whatever they can to encourage operators to broaden the experience of young employees by facilitating exchanges, attendance at conferences etc, and that their career progression gives early responsibility.
8. The task group recommends that the national committees (proposed in paragraph 6.1.5) should initiate a repeat, in their own countries, of the survey of supply and demand for nuclear scientists and engineers carried out in the US by NEDHO.
9. It is recommended that the CNRA invites one of the national committees (proposed in paragraph 6.1.5) to assemble information on mentoring schemes as a basis for the development of a specification for such a scheme. It is recommended that that committee then develops a specification and pilots a trial. The specification and trial details should be made available to other national committees through the CNRA.

1. BACKGROUND

1.1 The Committee on Nuclear Regulatory Activities (CNRA) of the OECD/NEA, in a report published in 1998 [1], identified the maintenance of nuclear safety competencies in the regulatory authorities as one of the most critical challenges to effective regulation of the nuclear power industry in Member countries in the coming decades. The challenge arises partly from the age profile of staff in the regulatory bodies, which could result in the loss of much of the present nuclear safety knowledge base due to retirements over the next decade or so, and partly from a decline in the numbers of students graduating from courses in nuclear science and engineering and becoming available for recruitment to fill vacancies left by retirements. Whatever the future of nuclear generation programmes, i.e. whether or not new nuclear power plants are built in Member countries, there will be an ongoing requirement in the regulatory bodies for several decades to recruit qualified staff to fill the vacancies left by retirements and to preserve the present knowledge base.

1.2 In many Member countries, the age profile of staff in the nuclear power industry is similar to that in the regulatory bodies, with many retirements inevitable over the next decade. The industry will therefore be competing with the regulatory bodies to recruit suitably qualified graduates. Whilst recruitment to the industry is a matter for the industry, the regulatory bodies have a legitimate interest in seeing that the nuclear power facilities which they regulate remain adequately staffed with suitably qualified and experienced personnel.

1.3 If no action is taken to redress the decline in the numbers of students graduating in nuclear science and engineering, a shortfall between supply and demand for graduates in the disciplines could reach critical proportions in some Member countries within a decade or so and if no action is taken to preserve the present knowledge base, much of the knowledge base could be irretrievably lost. The CNRA therefore resolved that a workshop should be held to identify ways of recruiting, educating, training and retaining staff, so to preserve an adequate level of staffing and an adequate nuclear safety knowledge base in both the industry and the regulatory bodies. The workshop was held in Budapest from 12-14 October 1999. A summary report [2] and a full report [3] have recently been published. The workshop produced a number of actions for

participants to take forward and a number of recommendations for consideration by the CNRA. As a first step in its response to those recommendations, the CNRA set up a task group commissioned to bring forward specific practicable proposals to implement the recommendations. The task group's terms of reference are reproduced at Annex 1. In this report, the task group focuses on the assurance of competencies essential to the operation and regulation of nuclear power plants and nuclear power programmes.

1.4 The task group notes that Signatories to the Convention on Nuclear Safety [4] have an obligation to address these issues. Specifically, Article 8.1 of the Convention states that:

“Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7 and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.”

Article 11.2 of the Convention states that:

“Each Contracting Party shall take appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.”

It is clear that Signatories to the Convention cannot leave the provision of suitably-qualified and experienced staff for nuclear installations and regulatory bodies entirely to the workings of market forces but have a responsibility to take whatever steps are needed to ensure that such staff are available throughout the lifetime of such installations, and that means until they are decommissioned and no longer pose a radiological hazard.

2. THE BUDAPEST WORKSHOP

2.1 The workshop was organised by the CNRA in conjunction with the Hungarian Atomic Energy Authority and was attended by 28 participants from 13 countries and two international organisations, the International Atomic Energy Agency (IAEA) and the OECD/NEA. The workshop received presentations of results of two prior studies, one initiated by the OECD/NEA and the other by the US Nuclear Engineering Department Heads Organisation (NEDHO), together with papers from participants dealing with topics ranging from the identification of essential nuclear safety competencies and facilities to specific initiatives already taken in their countries to ensure the retention of essential competencies and facilities.

2.2 Initiatives already taken in Member countries and reported at the workshop are summarised in Chapter 5 of this report, but there were general points that emerged in the course of discussion at the workshop that provide useful background to the reader of this report and guidance to the formulation by the task group of specific recommendations to the CNRA. These are listed below in paraphrased form.

- The situation varies between countries and remedial measures that are appropriate to one country may not be appropriate to another.
- There are no recruitment problems in countries that are still developing their nuclear generation programmes (France, Japan and the Republic of Korea) or, for different reasons, in Central and Eastern European countries
- Government confidence in nuclear power leads to a more supportive perception amongst the public.
- Political factors (government attitude) and the actions of pressure groups influence young people but there is increasing awareness of issues such as the link between CO₂ emissions and climate change, the concept of sustainable development and the need for security of supply.

- There are new technological challenges that can become attractive areas for work including plant life extension, living safety cases and research into ageing issues, decommissioning and waste management, also challenges arising from changes in weapons programmes.
- There is a continuing need for nuclear safety research capability to address residual concerns and any issues that may emerge in the future. It was noted that research attracts the most able university faculty members and students and contributes strongly to the maintenance of competencies.
- Countries that have imported nuclear plant and expertise may have to become self-sufficient if the former exporting countries lose the capability of providing those services.
- The liberalisation of the electricity market presents additional challenges to the regulators, although nuclear operators contend that the commercial pressures lead to improved safety levels. (Reference [5], not available to the workshop, is relevant to this issue.)
- There is a need to regenerate teaching capacity already lost.
- There is a need for “softer skills” both in the industry and in the regulatory bodies.¹
- Governments cannot avoid their responsibilities to maintain energy options, independent and effective regulation and the necessary educational system to support energy options and effective regulation.

2.3 There are two groups of recommendations embedded in the workshop reports, one group addressed to workshop attendees and another group addressed to the CNRA. The first group relates to initiatives already in place in at least one Member country that might be effective in other Member countries, the second group relates to initiatives that require collaboration between Member countries and/or international organisations and for which the CNRA might act as catalyst. In Chapter 6 of this report the workshop recommendations

1. The term “softer skills” was used at the Budapest workshop to mean the skills included in the definition in Annex 2 of this report, which is close to the IAEA definition of the term, plus skills related to the assessment of human and organisational performance.

are discussed and specific recommendations from the task group for action by the CNRA to implement the workshop recommendations are formulated.

2.4 The need for urgent action comes out very strongly from the summary report on the workshop [2]. The need is encapsulated in the following sentences quoted verbatim from the Executive Summary:

“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 loss. 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.”

3. OVERVIEWS OF PRIOR STUDIES

Prior to the Budapest workshop there had been two studies of the problem in recent years, one initiated by the OECD/NEA and the other by NEDHO. The study reports are summarised in sections 3.1 and 3.2 of this report. In response to the NEDHO study, the US DOE Office of Nuclear Energy invited the US Nuclear Energy Research Advisory Committee (NERAC) to establish a panel to consider the issues raised by the NEDHO studies. The panel's report was made available to the task group in final draft form and is summarised in sub-section 3.2.4.

3.1 NEA/NDC Study (1998)

3.1.1 The CNRA's concern for the maintenance of nuclear safety competencies was reinforced by the results of a comprehensive study of trends in nuclear education and training in Member countries over the period 1990 to 1998, carried out by an Expert Group set up under the auspices of the Committee for Technical and Economic Studies on Nuclear Energy Development and Fuel Cycle (NDC) of the OECD/NEA. The study is referred to in this report as the NEA/NDC study. A final draft of the full report on the study [6] was made available to the task group prior to its first meeting and was presented at the meeting. A summary report [7] and the final report [8] were subsequently published.

3.1.2 In one sense the scope of the NEA/NDC study was wider than the task group's remit, which focuses on the assurance of competencies essential to the operation and regulation of nuclear power plants and nuclear power programmes. The NEA/NDC study recognised that mankind enjoys many other benefits from research in nuclear science and from applications of that research in other fields, for example the medical field and the development of advanced materials and components, and therefore addressed nuclear education and training in the widest sense. In another sense, the scope of the NEA/NDC study was narrower than the task group's remit in that it did not address issues such as the definition of the competency frameworks essential to the operation and

regulation of nuclear power plants, the matching of the provision of competencies to the requirement, or the preservation of the present knowledge base.

3.1.3 The study report points out that:

“Whatever the future of nuclear power generation in Member countries, even if no new nuclear power plants are built, nuclear power plant safety competencies will be required for several decades safely to manage the legacy of decommissioning existing nuclear power plants and the management of the resulting radioactive wastes.”

3.1.4 To initiate the study, a questionnaire was sent in mid-1998 to 196 organisations in 16 Member countries including universities (119), nuclear research institutions (17), nuclear power generators (30), nuclear engineering companies (22) and nuclear regulators (8). The study report was also informed by detailed situation reports relating to and submitted from individual Member countries. The completed questionnaires and individual country reports revealed considerable variations in the situation between Member countries, but must be interpreted with some caution because of probable differences between responding organisations in their respective definitions of nuclear education and training courses. For example, it is apparent that some courses that were included in the returns from universities as undergraduate courses in nuclear science and engineering contained only short taught modules or project work in nuclear subjects.

3.1.5 The returns indicated an apparent 10% overall decrease in the number of degrees awarded at bachelor's level, with most of the decrease occurring between 1995 and 1998. At master's level there was little change: a small increase between 1990 and 1995 and a similar reduction between 1995 and 1998. At doctorate level there was a 26% increase over the period, with no evidence of a downturn. As stated, the returns indicated considerable variations between Member countries, with the United States showing the largest decrease at bachelor's level while countries such as France and Japan showed small increases. On the basis of evidence referred to in paragraph 3.1.8 below, it was the collective judgement of the Expert Group that the nuclear content of many courses leading to a bachelor's degree and included in the returns had declined over the period and so the reduction in the pool of knowledge at that level was greater than the 10% quoted above, with adverse implications for the numbers of graduates suitably qualified for registration for courses at master's and doctorate level.

3.1.6 The returns also indicated some worrying trends, in some Member countries, in the numbers and age profile of faculty members teaching nuclear science and engineering. For example, in the United Kingdom and the United States, the numbers of faculty members had declined and, of those remaining, the largest fraction was in the 51 to 60 age group. Conversely, in France and Japan the numbers had increased with the largest fractions in lower age groups, most noticeably in France where the largest fraction was in the age group 21 to 30.

3.1.7 The returns indicated that the facilities available to support nuclear education and training were reduced in number and were ageing. Seven research and training reactors had been decommissioned and no new research and training reactors commissioned (although one such reactor is under construction in Germany).

3.1.8 There was evidence that universities had to a certain extent responded to the changing needs of the nuclear power industry by introducing courses related to the fuel cycle, waste management technology and radiochemistry. But some courses, formerly focusing principally on reactor physics and engineering, had been diluted and broadened to include, for example, medical applications of nuclear science and radiation health engineering. Some courses had been merged with mechanical engineering, energy-related or environmental science courses and their nuclear content inevitably reduced. On the other hand, some of the disciplines essential to the assurance of nuclear safety, such as reliability, safety systems and some aspects of thermo-hydraulics that are particularly relevant to nuclear reactors are now included in general engineering courses.

3.1.9 The returns from research institutions, power generators, engineering companies and regulators, i.e. the organisations employing graduates in the discipline, showed a rather different situation in that the overall number of trainees completing in-house training courses and the overall number of man-hours of training had increased quite significantly over the period covered by the study. The in-house training courses included not only the practical skills that one would expect to be imparted through the medium of in-house training courses, but also theoretical courses that one would expect the universities to provide. Paradoxically, the increased provision of in-house training was, according to the returns, achieved by fewer instructors, who in most countries were younger than their university counterparts.

3.1.10 There was evidence from the study of the development of some successful collaborations between groups of universities and between universities and research institutions, power generators etc. to provide the required courses; also evidence of some successful initiatives to combat the

negative public perception of nuclear science and engineering, hence to increase enrolments to nuclear courses.

3.1.11 Overall, the results of the study reveal a downturn, over the period 1990 to 1998, in the numbers of students graduating at bachelor's level, but with marked differences between Member countries. There is some evidence of a recent downturn in the numbers of students graduating at master's level but a continuing increase in the numbers graduating at doctorate level. There is evidence from many Member countries of ageing university faculty members and facilities and of greater reliance by employers on in-house training programmes. The Member countries that defy these trends are those with strong nuclear power programmes, particularly France and Japan.

3.1.12 The summary report lists 12 recommendations, which are reproduced in Chapter 7 of this report, where the task group reflects on the extent to which its recommendations, made to take forward those from the Budapest workshop, also address those from the NEA/NDC report.

3.1.13 In the UK, there has been a positive response to the NEA/NDC report. Following a re-run of the survey by the NII [9], to assemble the most recent UK data, a forum on Nuclear Education and Training was jointly sponsored by the Government's Department of Trade and Industry (DTI) and the Health and Safety Executive (HSE). The forum was attended by more than 100 delegates representing government departments and agencies, nuclear facility operators and universities. The forum concluded that the issue of a declining nuclear education sector is a matter of concern and agreed to co-ordinate a national response through a government-led steering group with industry sector based working groups. A report on the proceedings will be available on the HSE web site in April 2001.

3.1.14 As noted in paragraph 2.2, there are certain initiatives in place in some Member countries that implement some of the recommendations from the NEA/NDC report. The initiatives, and experience to date of their success, are described in Chapter 5 of this report.

3.2 NEDHO Study (1998/99)

A report [10] published by the US Nuclear Engineering Department Heads Organisation (NEDHO) in 1999 summarises the outcomes of two workshops, held respectively in November 1998 and November 1999, also the results of a survey of the expected supply of nuclear engineers and anticipated demand, in the United States, over the next few years.

3.2.1 Survey of supply and demand

The survey returns indicated that the situation in the United States is more severe than the overall picture revealed by the NEA/NDC survey of OECD Member countries (which included the United States). For example the returns, when compared with the returns of a survey conducted in 1992, indicated reductions in enrolments of 72% for courses at bachelor's level and 46% for courses at master's level. The shortfall between the supply and demand for nuclear engineers is expected to increase monotonically from 363 in 1998/1999 to 468 in 2002/2003, although the forecasts are derived by extrapolation from the returns of the 52% of the employing organisations that responded to the survey.

3.2.2 The 1998 Workshop

The 1998 workshop identified perceived problems and possible solutions for consideration. The problems and solutions, paraphrased, were grouped as follows:

Problems:

- a shortfall between the supply of and demand for qualified nuclear engineers;
- a poor image of the discipline: nuclear engineering is perceived to be a stagnating field, offering few career opportunities;
- a need to improve communication and co-operation between the major constituencies, i.e. industry, academy and government;
- a decline in the number of university research reactors.

Solutions:

- quantify the imbalance between supply of and demand for qualified nuclear engineers;
- diversify nuclear engineering curricula: nuclear engineering departments should diversify their curricula while continuing to offer core competencies in nuclear power;
- improve communications and marketing: the nuclear community needs to communicate the need for nuclear power and the wide range of interesting, challenging and rewarding careers available in the field today and in the foreseeable future;

- creation of partnerships: universities, industry and governments need to form partnerships to address the major issues facing the nuclear community.

3.2.3 The 1999 Workshop

The 1999 workshop identified six major issues that need to be addressed to solve the supply/demand problem:

- Issue 1. Declining enrolment: which has led to closures and mergers of departments and a reduction in the curriculum on offer.
- Issue 2. Lack of excitement in the field: which does not possess the allure of some other fields and cannot attract students in competition with more attractive disciplines.
- Issue 3. Jobs versus careers: potential students are looking for exciting, challenging and rewarding careers and do not see careers in the nuclear industry as offering those attributes.
- Issue 4. Low visibility: the discipline suffers from low visibility and a lack of understanding of the breadth of the field.
- Issue 5. Industry needs engineers of all types, not just nuclear: there is a shortage of engineers of all disciplines.
- Issue 6. Recruiting of graduates needs to be improved: industry needs to do a better job of recruiting graduate engineers, more than a quarter of whom do not go into industry.

3.2.4 DOE/NERAC Report (2000)

In November 1999, the US DOE's Office of Nuclear Energy, Science and Technology invited the Nuclear Energy Research Advisory Committee (NERAC) to establish a panel to consider the issues raised by the NEDHO studies. The outcome is a report issued in final draft form by the panel in May 2000 [11] for consideration by NERAC and DOE. The panel recognised the strategic importance to the United States of the maintenance of competencies in nuclear science and technology, not only in relation to nuclear power generation but also to national security and to advances in other fields such as medicine. The panel made a number of recommendations for DOE assistance to the universities, which were grouped under three headings.

Recruitment of faculty and students

The first group of proposals include:

- the provision of additional funding to support doctoral fellowships and scholarships for study at master's level;
- the provision of additional funding to expand the Nuclear Engineering Educational Research (NEER) programme which provides funding to support research in universities, the additional funding to include provision for the establishment of grants for basic research by junior faculty members;
- support for a national programme of outreach to raise public awareness of the benefits to be derived from nuclear science and engineering.

Support for research and training reactors

The panel considered research and training reactors to be an important part of the nuclear science and engineering infrastructure that must be maintained. The second group of proposals include:

- continuation of the present provision of funding for reactor refuelling, operational instrumentation and reactor sharing;
- additional funding for competitive peer-reviewed awards for reactor improvements to assist with research, training and/or educational outreach.

Collaboration with DOE laboratories

The third group of proposals were aimed at increasing collaboration between universities and DOE laboratories by:

- increased funding for fellowships to support top graduate students and interchange of staff;
- greater support of university research by DOE laboratories by, for example, the allocation of a percentage of their budgets for this purpose.

At the time of writing this report, the panel is tasked to advise on the national need for facilities such as university research and training reactors and to develop criteria for determining which university reactors should be supported.

4. DEFINING THE REQUIRED COMPETENCIES

4.1 The starting point for actions to assure nuclear safety competencies is to define the competencies required. This is a major task. For organisations operating nuclear installations, the competencies required are not only those required of the panel operators, supervisors and managers up to and including plant manager or director, but also those required of the whole range of maintainers and of scientific and engineering support staff. Depending on the type of installation, the scientific and engineering support staff may include physicists specialising in reactor physics, shielding and criticality, chemists and radiochemists, health physicists and engineers with the range of disciplines needed to maintain the safety case for the plant or to act as “intelligent customer” for any support services supplied by contractors or by a corporate support unit.² In recent years, the importance of human factors, in the broadest sense of the term, in the assurance of nuclear safety has been more fully appreciated and operators have recognised the need to have human factors expertise available to their organisations.

4.2 The regulators require a similar range of competencies within or available to their organisations, if they are to regulate effectively, but they may require a different balance between the disciplines. They may not require the panel operators’ or maintainers’ specific skills, but they do require a similar range of scientific and engineering disciplines to enable them critically to assess safety cases. It is also desirable, if not essential, for site inspectors to have had practical experience of plant operation. The fact that nuclear installations in many countries are operating under fully-commercial conditions, resulting in pressures to reduce operating costs, reinforces the need for the regulators to have the expertise to assess the adequacy of staffing levels and the efficacy of management structures, also the influence with senior management, at any plant at which they perceive management shortcomings, to initiate appropriate corrective action. A report published by the OECD/NEA [5] has concluded that:

2. It is recognised that in organisations operating nuclear facilities, support services are often provided by contractors or by a corporate support unit.

“The regulator will have to consider how its existing technical skills will be maintained and what new skill sets and competencies must be added to the regulatory staff, particularly in areas such as market economics, finance, business management, safety culture and organisational issues.”

As examples of these new skills and competencies, in the course of its work the task group was provided with a report [12] prepared for the Canadian Nuclear Safety Commission on the development of a methodology for the review and assessment of organisations and management, also with a paper [13] on the management shortcomings, their symptoms, causes and recovery, at Ontario Power Generation. The OECD/NEA has also published a report exploring possible regulatory response strategies for dealing with declining safety performance when the outward manifestations of that performance suggest that there may be fundamental safety culture problems [14] That report is a sequel to an earlier report discussing how a regulatory body recognises and addresses safety performance problems that may stem from safety culture weaknesses [15].

4.3 The IAEA has done much work in the area of defining the nuclear safety competencies required by regulators and operators and offers, in co-operation with training organisations in its Member States, a wide range of training opportunities. A paper presented at the Budapest workshop [16] describes the IAEA’s training activities for regulators and gives an indication of the content of the courses. A draft Safety Guide [17] addresses the staffing and training needs of regulatory bodies. The IAEA has also completed the development of a document [18], to be published in 2001 in the TECDOC series, on the competency framework for regulatory body staff and intends to test its practical application in the form of a case study. Early drafts of the document were made available to the task group during the course of its work. It is the view of the task group that this document presents a comprehensive generic competency framework for regulatory bodies. There is a high degree of commonality in the requirements of regulatory bodies and the TECDOC will provide guidance on the common core of requirements. In the area of training and qualifications for nuclear power plant (NPP) personnel, a guidebook [19] on NPP personnel training and its evaluation and several TECDOCs have been published. An international working group was established by the IAEA in 1994 and provides advice on its current and future activities in this area. A safety guide [20] and a safety report [21] on the building of competency and the provision of training in the field of radiation protection and on the safe use of radiation sources are to be published by the IAEA.

4.4 Many national regulatory bodies have developed their own profiles of competencies essential to effective regulation, in some cases drawing on the

work of the IAEA. An example, a competency profile for an Intermediate Project Officer [22], was made available to the task group by the Canadian Nuclear Safety Commission (CNSC). There will inevitably be some differences between the competencies required by regulatory bodies in different countries, reflecting differences between the processes of regulation in the different countries. There will also be some differences between the specific expertise required in different countries. For example, the UK Nuclear Installations Inspectorate (NII) requires expertise in the effects on graphite of long-term exposure to the reactor environment, an area of expertise not likely to be required by regulatory bodies in other countries.

4.5 The nuclear plant operators have also developed competency frameworks essential to the safe operation of their plants. An example from the Finnish operator TVO [23] was presented at the Budapest workshop. These competency frameworks reflect the process of the management of safety in their organisations and the individual skills required for the safe operation of their specific plant. There will be differences between the requirements of different operators but again there will be a high degree of commonality between the requirements of different operators and, as noted above, between the requirements of the operators and those of the regulators.

4.6 To summarise this overview of the work done on the defining of the competencies required for the safe operation and effective regulation of nuclear installations, operators and regulatory bodies in many countries have developed competency frameworks for their own purposes. Much work has been done by the IAEA to define core competency frameworks for regulatory bodies. It is the view of the task group that the IAEA work on a core competency framework for a regulatory body would provide a starting point for the development by national regulatory bodies of competency frameworks suitable for their own circumstances, where these have not already been developed.

5. PROVISION AND RETENTION OF COMPETENCIES EXAMPLES OF BEST PRACTICE

Historically, the science and engineering disciplines required by the suppliers and operators of nuclear plant have been taught by universities on programmes at bachelors, masters and doctoral level, set up specifically for the purpose. Many of the programmes went beyond the teaching of the basic disciplines and included elements of, for example, the design of a nuclear plant involving the synthesis of the basic disciplines and the optimisation of parameters best to satisfy conflicting requirements. In many countries, the programmes were set up with government encouragement and with government funding for major items of equipment such as research and training reactors, fluid mechanics and heat transfer rigs, radiochemistry laboratories etc. Many of the teaching staff were recruited from government research institutions, having had extensive experience of research, development or design in the reactor or weapons fields. The graduates from these programmes were much in demand by the suppliers and operators of nuclear plant and many were sponsored on the programmes by those organisations. Specific, plant-related information was provided, particularly by the operators, by means of in-house courses, generally taught by their own employees. The regulatory bodies have, historically, recruited well qualified and experienced staff from the nuclear plant suppliers and operators. The reduced recruitment to the university programmes, which have supplied the “feed stock” to the recruitment chain, the consequent demise or dilution of many of the programmes and the ageing of university staff and facilities, highlighted and quantified by the NEA/NDC and US NEDHO studies, are one of the root causes of current concerns. Initiatives have been taken in several countries to arrest the decline of university programmes and to combat the potential threats to the assurance of essential nuclear safety competencies that could otherwise result from the decline of university programmes and the consequential shortfall in the numbers of graduates in nuclear sciences and engineering. In the following sections, some of these initiatives which, in the view of the task group, represent best practice and could have wider application, are reviewed. No attempt was made to ensure that the list is exhaustive. It includes examples that were brought to the attention of the task group, classified by the nature of the initiative.

5.1 Support for university programmes

Direct support by government

5.1.1 The recommendations of the US NERAC panel (paragraph 3.2.4), if accepted and implemented by the US DOE, would represent a good example of a positive government response to the situation. It is acknowledged by the task group that this solution to the difficulties being experienced by the universities, i.e. direct financial support for nuclear programmes and facilities, is unlikely to commend itself to some governments, whose approach is to leave the fate of individual university programmes to the university authorities, who cannot disregard market forces. However, there are examples described below of actions taken by regulatory bodies, within their delegated powers, and by industry' to help arrest the decline in university programmes.

Support by the national regulatory body

5.1.2 The Swedish Nuclear Power Inspectorate (SKI) supports two professors in appropriate disciplines, one in Nuclear Power Safety at the Royal Institute of Technology (KTH) in Stockholm and one in Nuclear Safety and the Interaction of Man, Technology and Organisation at the University of Stockholm.

Joint support by the regulatory body and industry

5.1.3 SKI, together with the Swedish domestic nuclear power plant supplier (ABB Atom) and the Swedish nuclear power plant operators, have for many years supported students at KTH. The nature of the support is described in a paper presented at the Budapest workshop [24]. This collaboration has recently been extended to include other Swedish universities and institutes of technology, to form the Swedish Nuclear Technology Centre. The principle role of the Centre is to conduct research of high quality into issues of residual or developing concern to SKI and the operators and, at the same time, to educate and train students to doctorate level.

5.1.4 In a recent development in the UK, the NII played a leading role in the setting up of an agreement to support the last remaining civilian master's level course in the UK specifically related to nuclear power plant, at Birmingham University. A feature of the agreement, described in a paper presented at the Budapest workshop [25], is that the major nuclear site licensees and the NII

collectively provide financial support for a number of students, sufficient to maintain the viability of the course.

Support by industry

5.1.5 In another recent development in the UK, British Nuclear Fuels Ltd (BNFL) provides both financial and scientific support for a Centre of Excellence in Radiochemistry at Manchester University. The Centre of Excellence concept formalises a recent trend in the UK for companies each to concentrate their funding of university research on a small number of universities. The funding supports a professor and other teaching and research staff and is enabling the refurbishment of a suite of radiochemistry laboratories. The Centre is becoming an international hub for those working in radiochemistry, in both academia and industry. It gives BNFL access to knowledge it needs and ensures that the overall decline of radiochemistry in UK universities is reversed.

5.1.6 In a similar development, there is a current proposal to establish a Northwest Multi-Disciplinary Nuclear Decommissioning Technology Centre (NUDEC) at the University of Manchester Institute of Science and Technology (UMIST) and Salford University. The proposed NUDEC would be funded by a consortium of some 14 companies and will, if successful, bring together expertise from a number of universities to form a “virtual” nuclear decommissioning technology centre.

Collaboration between universities

5.1.5 In Belgium, a group of four universities in the French Community have, for several years, been pooling their resources and running a successful joint postgraduate course in nuclear engineering in co-operation with the nuclear energy research centre of Mol (SCK•CEN) and the industry. Such collaboration is found to be practicable in Belgium, where the distances between the collaborating institutions are not great. The evolution of the joint course is described in another paper presented at the Budapest workshop [26]. Plans for the further evolution of the course include co-operation with the institutions running a similar course in the Flemish Community in Belgium and with the French Institut National des Sciences et Techniques Nucléaires are seen as a first step towards the development of a European network.

5.2 Outreach and the raising of public perception

The present low level of enrolment to nuclear courses is believed to be largely due to a poor public perception of nuclear generation, which is seen to be in decline and offering poor career prospects. The evidence for this belief is the buoyant state of enrolments to nuclear courses in countries with ongoing programmes of nuclear generation, as revealed by the NEA/NDC Study [8]. An improved public perception of nuclear generation might be expected to increase in the enrolment to university courses, in those countries where enrolments have declined. It is probable that the most effective way of improving public perception of nuclear generation, and recruitment to nuclear courses, would be for governments to commit themselves to the retention of the nuclear option. In many Member countries this is unlikely to happen in the foreseeable future because government policy is to leave the resolution of the energy mix issue entirely to market forces. However, one successful scheme to raise recruitment has been reported by the US NEDHO.

US universities' contacts with schools

5.2.1 The US NEDHO Study [10] reports successful outreach by some US Nuclear Engineering Departments to school teachers and students, resulting raised numbers of enrolments.

A role for the Young Generation Network

5.2.2 The Young Generation Network (YGN), which operates within the framework of the European Nuclear Society (ENS), is well established and active in many Member countries. It is the view of the task group that the YGN, and similar organisations in other countries, because of the age range of its members and their more recent student experiences, could play an effective role in outreach to schools and colleges.

5.3 In-house courses

As already noted, in-house courses generally do not cover basic nuclear sciences and engineering disciplines in great depth. Their purpose is to present plant-specific information, which is best presented by the operator's own staff who have the detailed knowledge and experience of the plant. In large organisations, operating a number of similar plants, these courses are often run in a central corporate training facility. The evidence from the NEA/NDC

Study [8] is that these in-house courses remain viable, not threatened by falling student numbers or by ageing staff and facilities.

Military colleges

5.3.1 In countries with military nuclear programmes, the military authorities have established their own nuclear courses in military colleges. Unlike most civilian in-house courses, some courses in the military colleges do present the basic nuclear sciences and engineering disciplines in at least as great a depth as university programmes at master's level. Historically, these courses have been a source of nuclear-educated and trained personnel for the civil nuclear industry and the regulatory bodies, since many ex-military personnel are recruited by the civilian organisations when they complete their military careers. These courses were generally excluded from the NEA/NDC Study. The recent survey by the UK NII [9], undertaken to update the UK-related information in the NEA/NDC Study, indicates that the output of nuclear-educated and trained graduates from the UK Royal Navy's Department of Nuclear Science and Technology at HMS SULTAN represents a significant fraction of the total UK output, particularly at levels below masters degree. It is understood that some of the courses are now open to civilian use. This is an encouraging development, although security issues may limit civilian use of some of these courses.

Paks

5.3.2 Initially set up as an in-house maintenance training facility at the Paks Nuclear Power Plant in Hungary, with the assistance of the IAEA, the facility has evolved into the Paks Maintenance Training Centre, described in a paper presented at the Budapest workshop [27]. The Centre is now used for the training of maintenance staff from nuclear power plants in other countries. This is an example of an in-house course that has evolved into a successful example of international collaboration.

5.4 Retention of essential research capability

One of the concerns highlighted at the Budapest workshop is the closing down of nuclear safety research facilities. There is a need to ensure that the capability to research residual nuclear safety issues, and unforeseen issues that may arise in future, is retained.

OECD/NEA/CSNI Study

5.4.1 An OECD/NEA Group of Senior Experts on Nuclear Safety Research Facilities and Programmes, reporting to the Committee on the Safety of Nuclear Installations (CSNI), has investigated the implications of the decrease of the level of nuclear safety research funding and the untimely shutdown of essential research facilities and capabilities. It has prepared a list of essential and unique facilities, under threat of immediate closure, in the areas of thermal-hydraulics and severe accident research, and made recommendations for their preservation and future use through international collaboration. It has also identified areas where essential capabilities are in danger of disappearing or being dispersed in the immediate future, and made recommendations regarding the organisation of Centres of Excellence where facilities and teams of experts could be maintained in activity to ensure the continued availability of advanced knowledge essential to future nuclear safety research programmes. The Group has also made recommendations regarding the setting up of data banks, the establishment of networks of experts and research facilities and other forms of international collaboration. A report will be published in the Spring of 2001 [28].

UK Essential Research Capability Model

5.4.2 An example of good practice to ensure the retention of essential research capability, brought to the attention of the task group, is the UK NII's Essential Research Capability Model. The NII and the nuclear site licensees have implemented a procedure to ensure the maintenance of essential resources, including both research facilities and specialist personnel. The essential resources are referred to variously as "Essential Research Capability" and "Key Teams". In reality the procedure is effective beyond purely research in that the research personnel are in many cases engaged also on safety analysis and safety case support work. The procedure is implemented through fourteen Technical Working Groups (TWGs) that were set up under a committee called the Industry Management Committee (IMC) to manage the nuclear safety research programme. Each TWG comprises technical specialists from the NII and four licensee organisations and each focuses on one technical area. The TWGs annually assess the continued necessity for and the current viability of each resource. The outcome of the review is the identification of those resources whose future may be threatened for whatever reason and whose loss could have an impact on nuclear safety. If an essential resource were identified to be under threat the process requires pro-active support to be provided. This means that work would be generated to secure the continued viability of the resource. To date, pro-active support has been required for only a small number of facilities or teams.

International projects

5.4.3 There are many examples of international collaborative projects set up to address particular nuclear safety issues in a cost-effective manner that help to assure the retention of the necessary competencies. For example, the 1999 Annual Report of the OECD/NEA [29] outlines five current joint or co-operative projects and another OECD/NEA document [30] gives brief descriptions of many collaborative projects carried out over the period 1975 to 1999 in the area of computer code comparisons (International Standard Problem exercises).

5.5 Retention and control of competencies

UK models

5.5.1 The UK NII exercises regulatory control by the imposition of conditions, known as Site License Conditions (SLCs), on the nuclear site licensees. A new site license condition, SLC 36, has recently been introduced to control any proposed change to the licensee's organisational structure and resources that may affect safety. SLC 36 requires licensees systematically to define their organisational structure, the competencies required to operate safely and where the competencies are sourced. This is referred to as the "baseline assessment". Subsequent changes to the baseline structure require adequate justification, effected by means of a management of change procedure.

5.5.2 Related to this is a requirement for a licensee to ensure that, when safety-related technical support is provided by a contractor, sufficient knowledge and experience is available within the licensee's organisation to ensure that the licensee retains ownership of the safety case and the control of hazards. This is known as the "intelligent customer" concept. This is an important test for a licensee as the current trend in the UK is for the increased use of contractors to carry out safety-related work, with the potential for loss of ownership and control by the licensee. This requirement focuses not so much on the levels of technical resource and the range of competencies available to the licensee, but where the resources and competencies reside. The NII currently assesses licensees with respect to meeting the intelligent customer requirements.

5.5.3 The NII, as the regulator, has a requirement for access to independent specialist advice. With a contracting nuclear industry, independent advice is becoming more difficult to secure. The NII carries out an annual review of the availability of independent teams of specialists within external organisations.

The review identifies the number of teams available in each technical area and a judgement is made as to whether any pro-active support is needed. At present, teams in only two technical areas require pro-active support.

5.6 Retention of the nuclear safety knowledge base

The nuclear safety related knowledge base is vast and resides in different places and in different forms. The traditional forms include printed open-literature conference and journal papers, commercial and security-classified company and government reports, company files and data bases, drawings of specific plants, detailed descriptions of specific plants written in support of safety cases, etc. Access to the printed open-literature material, much of which is now also available on the Internet, presents no problem for future generations, provided the material is stored in a suitable manner. The concern is the potential loss of knowledge that resides in company files or only in the memories of the older generation. This information, if lost, would be difficult to re-generate. For example, the reasoning that led to decisions to build plants in certain ways would have been based on the experiences of those taking the decisions but possibly not fully recorded. It is this sort of knowledge, sometimes referred to as corporate memory, that needs to be captured before it is lost. There are several schemes, brought to the attention of the task group, that assist in the transfer of corporate memory from the older to the younger generation.

Design reconstitution

5.6.1 This is a Swedish initiative [24], in which young engineers are involved in in-depth safety reviews of existing plants, as a means of knowledge transfer. Periodic safety reviews of nuclear plant are required by regulatory bodies and involve an in-depth review of the safety of the plant against the original design intent and against current standards. By involving young engineers in these reviews, they bring a freshness of approach to the work and “tease out” the reasons why plants were built the way they were and are operated the way they are. This has been found to be an excellent vehicle for the transfer of knowledge and the tutoring of young engineers.

Recruitment and training of a new workforce in the US nuclear weapons programme

5.6.2 The US Congress, concerned about the potential loss of nuclear weapons expertise due to retirements, set up a Commission on Maintaining United States Weapons Expertise, tasked to review the efforts of the DOE to attract scientific, engineering and technical personnel to assure the ongoing safety and reliability of the US nuclear weapons stockpile. The Commission, in its report [31], acknowledges that the weapons programme faces all the challenges facing the civilian nuclear programme and makes 12 recommendations, several of which may be equally relevant to the civilian programme. These recommendations include the use of retirees to assist in the tutoring and/or training of recruits and in the safety review process. The recommendations also include the institution of a small select reserve of those with key skills to be recalled if required.

Activities of the Young Generation Network

5.6.3 The YGN organises activities designed to aid both the retention of the knowledge base and the career development of its members. In Sweden, for example, the activities of the YGN include seminars led by experienced scientists and engineers, conferences, educational visits and in-depth studies in small groups. These initiatives are described in greater detail in the Swedish paper presented at the Budapest workshop [24]. Similar YGN activities have been reported from other Member countries, including Belgium [32] and the UK [33].

The Belgian knowledge management project

5.6.4 It was brought to the attention of the task group that there are techniques under development for the retention of corporate memory. One example, designated the “knowledge management (KM) project”, is under development within Electrabel, the Belgian utility. The KM project has two aims. The first aim is to reconstitute a knowledge base relating to existing plants in an environment that permits the deposition of knowledge in a structured way and allows easy access. The second aim is to develop, at all levels within the Company, a culture in which critical knowledge is recognised, is seen as a major asset to be shared, and entered into the knowledge base. In the Generation Business Unit of the Company, a knowledge officer has been assigned to co-ordinate the initiatives and a steering committee appointed to guide and follow up progress.

The use of expert systems

5.6.5 Another technique, of which members of the task group are aware, is the use of expert systems to capture knowledge. One example, brought to the attention of the task group, is the use of an expert system to capture detailed knowledge of the operation of an Advanced Gas-cooled Reactor (AGR) fuel route. The objective of the project was to download into an expert system the knowledge of the operators in interpreting the load traces from the fuelling machine. The results were encouraging but highlighted the difficulty of capturing knowledge in sufficient detail that an expert system can be relied upon to interpret results correctly and safely.

6. RECOMMENDATIONS FROM THE BUDAPEST WORKSHOP

In this Chapter, the recommendations and proposed actions from the Budapest workshop are summarised. The task group has taken these recommendations and proposed actions as a starting point for the formulation of specific proposals to the CNRA, taking account of the examples of best practice outlined in Chapter 5. The recommendations from the Budapest workshop are shown in bold type within the body of the text. The task group's specific recommendations to CNRA are also shown in bold type and labelled "Recommendation".

6.1 Competency frameworks

6.1.1 The Budapest workshop report points out that work on the development of competency frameworks has been carried out by the IAEA and by regulatory bodies and nuclear plant operators in individual Member countries. The workshop report recommends that the work be encouraged and drawn together. To implement that recommendation, the workshop report proposes the following sequence of actions:

- Undertake an examination of the competency frameworks developed and published by IAEA, AECB (now CNSC) and Finnish organisations.
- Examine other recent international use of competency frameworks to assist in future development of the IAEA baseline documents.
- Initiate a review of Member country experience with competency frameworks to establish whether a revised IAEA document represents current best practice.
- Investigate the feasibility of carrying out job and task analysis for regulators and operators to provide some generic competency profiles.
- Establish a strategy for updating and developing the competency framework.

- Based on the revised competency framework identify the core competencies required currently.
- Identify the core training needs and availability of training facilities with the aim of identifying any gaps.
- Identify the core nuclear competency requirements and investigate approaches to preserving the competency.

Competency framework for a nuclear regulatory body

6.1.2 Much work has already been done by national nuclear regulatory bodies to develop competency frameworks. Some of this work was reported at the Budapest workshop. As noted in paragraph 4.3 of this report, the IAEA has also done much work towards the development of a generic competency framework for a regulatory body. An IAEA document entitled “A Competency Framework for Developing Training Programmes for Staff of Regulatory Bodies” [18] was presented to the task group as a draft. It is the view of the task group that the document, when published, will present a comprehensive generic competency framework for a nuclear regulatory body.

Recommendation

The IAEA generic competency framework for regulatory bodies is commended to the CNRA as a starting point for the development of competency frameworks for national nuclear regulatory bodies.

Competency framework for a nuclear plant operator

6.1.3 The development of competency frameworks for nuclear plant operators is a matter for the operators, but it is the legitimate business of the regulatory bodies to require them to do so. Many operators have done much work on the development of competency frameworks. Some of their work was also reported at the Budapest workshop.

Recommendation

The task group recommends that the CNRA should encourage the development of a generic competency framework for NPP operators, to be used by operators as a starting point for the development of competency frameworks appropriate to their own circumstances.

Periodic updating of competency frameworks

6.1.4 It is noted that the IAEA has in place procedures for the periodic review and re-issue of its documents and it is assumed that the Agency's procedures are adequate to ensure that its generic competency frameworks will be reviewed and reissued at appropriate intervals.

Education and training requirements

6.1.5 When the required competency frameworks for regulatory bodies and nuclear plant operators are in place, it will be possible to define the required knowledge base and the education and training facilities to which all regulatory bodies and operators should have access.

Recommendation

It is recommended that the CNRA encourages governments or government agencies to take the lead in the immediate designation or setting up of national committees comprising regulators, operators and educators, to ensure, as far as is practicable, that essential education and training facilities are identified and action taken to assure their ongoing viability.

6.2 Encouraging co-operation

6.2.1 The Budapest workshop identified the advantages to be gained from co-operation across education and research facilities and from interchange of staff and the pooling of resources. The key task was identified as the clarification of a few defined areas of co-operation and the identification of future areas of co-operation. To carry forward the task the report proposes the following sequence of actions:

- Establish the extent of co-operation schemes in use within Member countries.
- Examine graduate and postgraduate training arrangements that support the core competencies and identify areas suitable for further development of co-operative programmes.
- Examine the Swedish Centre for Nuclear Technology and the British Nuclear Fuels (BNFL) initiative to support radiochemistry and identify the key features.

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

Co-operation at national level

6.2.2 Several examples of co-operative schemes within Member countries were described at the Budapest workshop and have been cited in Chapter 5 of this report as examples of best practice. These include the Swedish Centre of Nuclear Technology and the BNFL/Manchester University Centre of Excellence in Radiochemistry, which are specifically mentioned in the workshop recommendations. Other examples cited in Chapter 5 include the support by a consortium of industrial and consulting organisations for the proposed UK Northwest Multi-Disciplinary Nuclear Decommissioning Technology Centre (NUDEC) at UMIST and Salford University and the collaboration between a group of four Belgian universities and the nuclear energy research centre of Mol (SCK•CEN) to run a joint postgraduate course in nuclear engineering. The key features of these examples of best practice are described in outline in Chapter 5 of this report and more fully in the referenced documents. The task group has recommended, in paragraph 6.1.5, the designation or setting up of national committees to ensure the retention of essential education and training facilities and recommends that the national committees are made aware of these examples of best practice in co-operation at national level.

International co-operation

6.2.3 The potential for international co-operation has been realised in the Paks Maintenance Training Centre, set up with the assistance of the IAEA and cited in Chapter 5. Another example cited in Chapter 5 is the proposed extension of the Belgian Universities' collaborative postgraduate course to include the French Institut National des Sciences et Techniques Nucléaires, seen as a first step towards the development of a European network. A third example is the collaborative Frederic Joliot/Otto Hahn Summer School in Reactor Physics, directed by a team from CEA/DRN Cadarache and Institut für Reaktorsicherheit Forschungszentrum, Karlsruhe, with the collaboration of other universities and institutes. A fourth example is the OECD Halden Reactor Project Summer Schools, devoted to reactor fuel safety, core materials and man-

machine interface. A fifth example is the Nuclear Law School being set up by the OECD/NEA and the University of Montpellier.

6.2.4 It is the task group's view that the examples cited here should be brought to the attention of the national committees referred to in paragraph 6.1.5 and that they are encouraged to consider where further international collaboration might best meet their national education and training requirements.

6.2.5 The IAEA General Conference passed, in 2000, a resolution urging the Agency to strengthen its work in the area of education and training in nuclear, radiation and waste safety. As a result, the IAEA is convening, early in 2001, Advisory Groups on the strategy and scope of a wide programme in these areas. Current activities include a six weeks course on nuclear safety being offered world-wide, in several languages, to junior professionals of NPP operators and regulators, also a postgraduate course and radiation protection. Other specialised courses and workshops are offered. A principal concern of the IAEA is, however, to ensure the sustainability of education at the national level. Specific programmes to train trainers and the use of distance learning are being increasingly used by the IAEA for this purpose.

Recommendation

The task group recommends that, through the national regulatory bodies, the examples of best practice in national and international co-operation (described in Chapter 5) should be brought to the attention of the national committees (referred to in paragraph 6.1.5) with a recommendation that they consider whether their national education and training requirements might best be met by adopting one or more of the examples of national and/or international co-operation.

6.3 Young Generation Network and similar organisations

6.3.1 The YGN of the ENS, which has networking arrangements with similar organisations outside Europe, has great vigour and a strong commitment to the promotion of the nuclear power option as a means of reducing greenhouse gas emissions and conserving hydrocarbon resources. In a paper to the Budapest workshop [34], a representative of the YGN asked two questions, firstly "what can industry do for young people?" and secondly "what can young people do?" In the workshop report, it was recommended that further use of such a network

will help to underpin actions in other areas such as encouraging co-operation. The report proposes the following actions to implement the recommendation:

- Establish a forum for improved contact with the Young Generation Network.³
- Utilise the Young Generation Network to develop an action plan for effective communication with schools and universities concerning science and technology.
- Review the Young Generation Network paper at the workshop and identify the key areas in which they could provide assistance.

6.3.2 The actions address the presenter's second question, but not his first question, "what can industry do for young people?" The task group believes that the YGN and similar organisations have the potential to be very effective in persuading school and university students to think seriously about careers in science and technology generally and in nuclear science and technology in particular and should be supported. The CNRA and national regulatory bodies cannot be seen to be promoting nuclear power but they can be seen to be encouraging recruitment to the industry given that the availability to the industry of adequate numbers of well educated and trained staff is essential to nuclear safety. It is therefore their legitimate business to give what assistance they can to the YGN and similar organisations. One way in which the older generation can help young people is by mentoring, which is addressed specifically in the next section of this report. Other ways include:

- facilitating attendance at conferences, workshops, topical meetings, etc.;
- facilitating exchanges of young people to broaden their knowledge and experience;
- giving young people early responsibility.

These actions are largely a matter for employers, but regulators do have some influence in that they have the authority to require operators to have in place arrangements for the training of staff. Attendance at conferences, workshops, topical meetings etc. is a useful component of a comprehensive training programme. Likewise, exchanges are an effective component of a

3. The name Young Generation Network has to be interpreted including the Young Generation Network of the European Nuclear Society and similar organisations outside Europe.

comprehensive training programme and could be encouraged, with appropriate sensitivity, by the regulators. Early responsibility is an important component of a young person's career development. It should be recorded that at least some of the professional and learned societies affiliated to the ENS provide financial support to allow young members to attend conferences etc.

6.3.3 Addressing the actions proposed in the workshop report, the inclusion of young persons in the national committees proposed at paragraph 6.1.5 would provide the required forum for contact with the young persons and would enable them to play a full role in the identification of essential education and training facilities and in putting in place arrangements to assure their ongoing viability. These national committees would provide the forum for discussion of the role that the YGN and similar organisations might play, for example, in raising the perception of nuclear power in schools and universities and of any other ways in which the industry might assist the work of them.

Recommendation

It is recommended that the national committees (proposed in paragraph 6.1.5) should include representatives of the YGN or similar organisations and that the committees are invited to do whatever they can to encourage operators to broaden the experience of young employees by facilitating exchanges, attendance at conferences etc, and that their career progression gives early responsibility.

6.4 Mentoring

6.4.1 The importance of having adequate mentoring arrangements in place for young scientists and engineers in industry has been widely recognised. The key task identified in the workshop report is **to** develop an approach (to the mentoring of young scientists and engineers). The report proposes the following actions to carry forward the task:

- Develop the specification and requirements for a mentoring scheme for young engineers.
- Examine methods of using modern communication techniques.

- Establish likely organisations that would facilitate and support such an approach.
- Establish a small group of people prepared to help in a pilot exercise.

6.4.2 Mentoring schemes, aimed at supporting the career development of young engineers, are well established in some Member countries, in particular by the professional engineering institutions. The organisations most likely to be aware of any such schemes in place to support young nuclear engineers are the YGN and similar organisations. Mentoring involves communication. Existing mentoring arrangements known to the task group generally involve a young engineer and his or her mentor located sufficiently closely for face-to-face contact to be practicable. This may not always be possible. It would be useful if the use of modern methods of communication, such as the Internet, were explored.

Recommendation

It is recommended that the CNRA invites one of the national committees (proposed in paragraph 6.1.5) to assemble information on mentoring schemes as a basis for the development of a specification for such a scheme. It is recommended that that committee then develops a specification and pilots a trial. The specification and trial details should be made available to other national committees through the CNRA.

6.5 Need for a strategic view

6.5.1 The final group of actions recommended in the Budapest workshop report relate to the development of a long-term strategy for addressing all the issues identified at the workshop. The proposed actions are:

- 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.
- Use the plan developed above as a tool to provide influence internationally.
- Identify any additional short-term actions based on the strategic plan.

6.5.2 The task group was set up by the CNRA as its implementation of the initial phase of the first action and the task group's recommendations, summarised in Chapter 8 of this report, will, if accepted by the CNRA, constitute the basic steps of a strategic plan. The CNRA may wish to initiate additional actions as a result of its consideration of this report.

6.5.3 The task group stresses the need for a long-term strategic view on assuring nuclear safety competencies, as recommended by the Budapest workshop. It is the task group's view that the CNRA should establish the elements of a long-term strategic plan to be used as a tool to provide influence internationally and to identify any additional short-term actions.

Recommendation

The task group recommends that the CNRA should appoint, from its own membership and/or other recognised experts, a small group to develop a long-term strategic plan to take forward the task group's recommendations and any other issues related to the assurance of future nuclear safety competencies, to monitor specific national and international activities in this area and to keep the CNRA informed of progress. It is further recommended that workshops similar to that held in Budapest in 1999 are held at regular intervals, in order to provide a mechanism for monitoring new developments and emerging issues.

7. CONSIDERATION OF THE RECOMMENDATIONS FROM THE NEA/NDC AND NEDHO STUDIES

This report so far has addressed the recommendations from the Budapest workshop and made specific practicable proposals to take forward those recommendations. In this Chapter the task group reviews the issues raised by the previous studies, i.e. the NEA/NDC and NEDHO studies summarised in Chapter 3 of this report, and considers the extent to which the task group's proposals also address the recommendations from those earlier studies.

NEA/NDC Study

7.1 The report on the NEA/NDC Study listed 12 recommendations, designated R1 to R12:

- R1 We must act now. The actions, described in subsequent recommendations, should be taken up urgently by government, industry, universities, research institutes and the OECD/NEA.
- R2 Governments should engage in strategic energy planning, including consideration of education, manpower and infrastructure.
- R3 Governments should contribute to, if not take responsibility for, integrated planning to ensure that human resources are available to meet necessary obligations and address outstanding issues.
- R4 Governments should support, on a competitive basis, young students. They should also provide adequate resources for vibrant nuclear research and development programmes including modernisation of facilities.
- R5 Governments should provide support by developing "educational networks or bridges" between universities, industry and research institutes.
- R6 Universities should provide basic and attractive educational programmes.

- R7 Universities should interact early and often with potential students, both male and female, and provide adequate information.
- R8 Industry should continue to provide rigorous training programmes to meet its specific needs.
- R9 Research institutes need to develop exciting research projects to meet industry's needs and attract quality students and employees.
- R10 Industry, research institutes and universities need to work together to co-ordinate efforts better to encourage the younger generation.
- R11 The Member countries should ask the OECD/NEA to develop and promote a programme of collaboration between Member countries in nuclear education and training.
- R12 The Member countries should ask the OECD/NEA to provide a mechanism for sharing best practices in promoting nuclear courses.

7.2 The following notes indicate the extent to which the 12 recommendations would be taken forward by the implementation of the proposals made in this report.

- R1 This report urges the prompt action called for by this recommendation.
- R2 The task group recognises that, in many Member countries, government policy is to leave the balance of the energy mix to market forces. However, the Convention on Nuclear Safety [4] commits governments to taking whatever steps are needed to ensure that suitably-qualified and experienced staff are available throughout the lifetime of nuclear installations, and that means until they are decommissioned and no longer pose a radiological hazard. The task group acknowledges that governments are most likely to discharge this commitment through the national regulatory bodies. The recommendations made in this report would implement the commitment by involving the regulatory bodies in the process of assuring the continuing provision of suitably-qualified and experienced staff.

R3, R4 and R5

These recommendations are closely linked to R2. Noting that regulatory bodies are agencies of government, the acceptance and implementation of the proposals made in this report would implement R3, R4 and R5.

R6 and R7

The proposals made in this report should assist the universities in the recruitment of students, hence in the provision of basic and attractive programmes.

R8 All the evidence suggests that the nuclear industry does provide rigorous training programmes to meet its specific needs. The task group makes no specific recommendations in this area.

R9 Realistically, research institutes, universities and the industry's research departments, will develop only research projects for which they can attract funding. Apart from "blue skies" projects funded by government research support agencies and possibly by charitable foundations, this means that they address only real nuclear safety issues. The task group's recommendations include the wider implementation, where appropriate, of examples of best practice in the support of essential nuclear safety research capability. This is probably the realistic limit of what can be done through the CNRA to promote exciting and attractive research.

R10, R11 and R12

These recommendations are closely linked and all would be implemented by the task group's proposals.

To summarise, with the exception of R8, the recommendations from the NEA/NDC Study would all be taken forward by the implementation of the task group's proposals.

NEDHO Study

7.3 The NEDHO survey illustrated very clearly and quantified the widening gap between the supply and demand for graduates in nuclear sciences and engineering in the US. So far as the task group is aware, the exercise has not been repeated in other Member countries. The task group recommends that national regulatory bodies should initiate a repeat of the NEDHO survey in their own countries. They have a legitimate interest in the results of such a survey and the data would strengthen their hand in the implementation of the task group's recommendations.

Recommendation

The task group recommends that the national committees (proposed in paragraph 6.1.5) should initiate a repeat, in their own countries, of the survey of supply and demand for nuclear scientists and engineers carried out in the US by NEDHO.

The recommendations made in the DOE/NERAC Report are very specific to US circumstances, but the task group's recommendations address all the issues identified in the 1998 and 1999 NEDHO workshops.

8. RECOMMENDATIONS TO CNRA

In this Chapter, the task group's recommendations to the CNRA, which are distributed throughout the report, are brought together, with references to the paragraphs in which the recommendations are made. The recommendations are intended as a package, but are presented here in order of priority.

Recommendation 1 (paraphrased from the quotation in paragraph 2.4)

The CNRA should act now because of the time lag to restore lost competencies.

Recommendation 2 (paragraph 6.6.3)

The task group recommends that the CNRA should appoint, from its own membership and/or other recognised experts, a small group to develop a long-term strategic plan to take forward the task group's recommendations and any other issues related to the assurance of future nuclear safety competencies, to monitor specific national and international activities in this area and to keep the CNRA informed of progress. It is further recommended that workshops similar to that held in Budapest in 1999 are held at regular intervals, in order to provide a mechanism for monitoring new developments and emerging issues.

Recommendation 3 (paragraph 6.1.5)

It is recommended that the CNRA encourages governments or government agencies to take the lead in the immediate designation or setting up of national committees comprising regulators, operators and educators, to ensure, as far as is practicable, that essential education and training facilities are identified and action taken to assure their ongoing viability.

Recommendation 4 (paragraph 6.1.2)

The IAEA generic competency framework for regulatory bodies is commended to the CNRA as a starting point for the development of competency frameworks for national nuclear regulatory bodies.

Recommendation 5 (paragraph 6.1.3)

The task group recommends that the CNRA should encourage the development of a generic competency framework for NPP operators, to be used by operators as a starting point for the development of competency frameworks appropriate to their own circumstances.

Recommendation 6 (paragraph 6.2.5)

The task group recommends that, through the national regulatory bodies, the examples of best practice in national and international co-operation (described in Chapter 5) should be brought to the attention of the national committees (proposed in paragraph 6.1.5) with a recommendation that they consider whether their national education and training requirements might best be met by adopting one or more of the examples of national and/or international co-operation.

Recommendation 7 (paragraph 6.3.3)

It is recommended that the national committees (proposed in paragraph 6.1.5) should include representatives of the YGN or similar organisations and that the committees are invited to do whatever they can to encourage operators to broaden the experience of young employees by facilitating exchanges, attendance at conferences etc, and that their career progression gives early responsibility.

Recommendation 8 (paragraph 7.3)

The task group recommends that the national committees (proposed in paragraph 6.1.5) should initiate a repeat, in their own countries, of the survey of supply and demand for nuclear scientists and engineers carried out in the US by NEDHO.

Recommendation 9 (paragraph 6.4.2)

It is recommended that the CNRA invites one of the national committees (proposed in paragraph 6.1.5) to assemble information on mentoring schemes as a basis for the development of a specification for such a scheme. It is recommended that that committee then develops a specification and pilots a trial. The specification and trial details should be made available to other national committees through the CNRA.

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Annex 1

CNRA TASK GROUP ON SPECIFIC ACTIONS FOR ASSURING FUTURE NUCLEAR SAFETY COMPETENCE

Terms of Reference

Background

At its November 1999 meeting, the CNRA decided to set up for one year a task group on Specific Actions for Assuring Future Nuclear Safety Competence. There are indeed major concerns arising from the long-term ability to preserve safety competence within the industry and the regulator, in particular because the number of enrollments in the fields of nuclear science and engineering are decreasing rapidly in most universities and engineering schools and because the nuclear safety competence is predominantly vested in the same age group. The time is rapidly approaching when this group will be retiring, over a period of a few years. These and other issues were discussed by the October 1999 CNRA Workshop on Assuring Nuclear Safety Competence into the 21st Century, organised 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. The Workshop made several suggestions, and brought out a number of interesting initiatives taken by Member countries. CNRA decided to follow future developments closely.

Terms of reference

- The task group will exchange information on relevant issues in Member countries and initiatives.
- In particular, it will consider issues and recommendations arising from the October 1999 Workshop and other suitable international meetings or reports.
- It will develop suitable practical proposals for national and international work.
- It will submit the proposals to the CNRA in a report to be completed and distributed well in advance of the Autumn 2000 meeting of the Committee.

Aspects to be considered

The October 1999 Workshop on Assuring Nuclear Safety Competence into the 21st Century identified important issues, in particular:

- time lag to replace lost competence (5 to 10 years), and the need for urgent action;
- retirements peaking over next 5-10 years;
- maintenance of core skills;
- establish competence profiles;
- train the trainers.

Particular attention was drawn to several specific aspects, including:

- the need for a long-term view and planning, because of the long-term strategic nature of the issues;
- enlist the help of the ENS Young Generation Network and similar organisations;
- encourage the development of IAEA documents on regulatory competencies;
- knowledge capture and advancement;
- need to maintain and develop appropriate safety research as catalyst for dynamic and attractive education programmes and co-operation between industry and education;
- the benefits of international collaboration.

Tentative schedule

February 2000	Formation of the task group
Early Spring 2000	1st meeting of the task group (distribution of tasks)
Early or late summer 2000	2nd meeting of the task group (preliminary draft report)
Autumn 2000	3rd meeting of the task group (final draft report)

Annex 2

DEFINITIONS

Competency: a group of related knowledge, skills and attitudes needed to perform a particular job.

Competency framework: the totality of the competencies required by an organisation in order satisfactorily to carry out its function.

Competency profile: the competency required by the holder of an individual post in order satisfactorily to carry out the duties of the post.

Softer skills: competencies related to personal and interpersonal effectiveness including, but not limited to, self management, teamwork, leadership and communication skills.

Annex 3

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