

HUMAN RESOURCE DEVELOPMENT
FOR NUCLEAR POWER PROGRAMMES:
BUILDING AND SUSTAINING CAPACITY

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PROCEEDINGS SERIES

HUMAN RESOURCE DEVELOPMENT
FOR NUCLEAR POWER
PROGRAMMES:
BUILDING AND SUSTAINING
CAPACITY

SUMMARY OF AN INTERNATIONAL CONFERENCE
ORGANIZED BY THE INTERNATIONAL ATOMIC ENERGY AGENCY
AND HELD IN VIENNA, 12–16 MAY 2014

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2018

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FOREWORD

The importance of having adequate competent human resources to ensure the safe, secure and sustainable management of nuclear power programmes has been understood for some time. In 2010, the IAEA held a successful international conference on this topic in Abu Dhabi, hosted by the Government of the United Arab Emirates. Since then, Member States and the IAEA Secretariat have been active in improving their education and training systems and processes, and enhancing networking and international cooperation. However, the issue of human resources was once again brought into sharp focus by the accident at the Fukushima Daiichi nuclear power plant. The subsequent IAEA Action Plan on Nuclear Safety called on Member States with nuclear power programmes and Member States planning to embark on such programmes to strengthen, develop, maintain and implement capacity building initiatives.

The IAEA International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity (Strategies for Education and Training, Networking and Knowledge Management) was held from 12 to 16 May 2014 in Vienna. The conference was intended to emphasize the importance of human resources and capacity building programmes and to review developments in the area of human resources globally, building on the work of the Abu Dhabi conference in 2010. The conference served as a forum to share experiences and best practices across governments, industry, and educational and research institutions. Much good work has been done in this area, and many good examples were presented throughout the conference; however, there was also recognition that more work needed to be done.

The conference was also intended to encourage Member States to adopt an integrated national approach to capacity building, led by governments, and to reach out to the next generation of nuclear professionals to ensure the continuity of human resource pipelines. These Proceedings highlight the key findings and recommendations of the meeting, as well as the conclusions of the conference president. The papers presented and discussed during the meeting are included on the attached CD-ROM.

The IAEA wishes to thank all the participants of the conference — particularly the Programme Committee, the session lead chairs and co-chairs, and the conference rapporteur, P. Gowin (Germany) — for helping to make this conference a success. Special thanks and appreciation go to the conference president, M. Ziakova (Slovakia).

The IAEA also acknowledges the generous support given by the Permanent Mission of France to the IAEA, the Permanent Mission of Hungary to the IAEA, the Nuclear Knowledge Management Institute, the Russian Federation's State

Atomic Energy Corporation 'ROSATOM', Texas A&M University and Thomas Thor Associates.

The IAEA officers responsible for this publication were B. Molloy, B. Pagannone and Z. Pasztory of the Division of Nuclear Power and S. Mallick of the Office of Safety and Security Coordination.

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The material on the accompanying CD-ROM has been prepared from the original materials as submitted by the authors

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INTRODUCTION

The International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity (Strategies for Education and Training, Networking and Knowledge Management) was organized by the IAEA and held in Vienna from 12 to 16 May 2014.

BACKGROUND

Participants in the IAEA's first major conference on the subject of human resources, the International Conference on Human Resource Development for Introducing and Expanding Nuclear Power Programmes, held in Abu Dhabi from 14 to 18 March 2010, placed a high value on the information exchanged and recommended that similar conferences be organized every four to five years. The participants also:

- Highlighted the need to broaden nuclear engineering and technology curricula to include 'soft' sciences, such as risk analysis, law and social sciences;
- Recognized that successful nuclear power programmes can succeed only with strong governmental and societal support;
- Requested more cooperation — locally, nationally and internationally — in building human resources for nuclear power programmes with the intent of overcoming isolationist trends.

In addition, other major global conferences, including successive IAEA General Conferences, the 2007 International Conference on Knowledge Management in Nuclear Facilities, and the 2013 International Conference on Nuclear Security have emphasized the importance of these topics.

Consequently, the IAEA organized the International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity (Strategies for Education and Training, Networking and Knowledge Management) in Vienna from 12 to 16 May 2014.

Capacity building is a major first step in ensuring a sustainable supply of suitably qualified human resources who are ready to assume their responsibility for the safe, responsible and sustainable use of nuclear technologies. Capacity

building, as defined by the IAEA¹, consists of four essential elements: human resource development; education and training; knowledge management; and knowledge networks at the national, regional and international level.

The IAEA's capacity building programmes cover all areas related to nuclear safety — including safe operation, emergency preparedness and response, and regulatory effectiveness — and seek to build on existing capacity building infrastructures. The importance of capacity building was underlined in the IAEA Action Plan on Nuclear Safety (2011), in which one of the actions called on Member States with nuclear power programmes, as well as Member States planning to embark on such programmes, to strengthen, develop, maintain and implement their capacity building programmes. Also, the critical role of human resources and capacity building in developing and maintaining nuclear infrastructure was reiterated by subsequent International Experts Meetings related to this topic.

The International Conference on Human Resource Development for Nuclear Power Programmes focused on the global challenges of capacity building, human resource development, education and training, nuclear knowledge management and the establishment of knowledge networks, including the themes reflected in the IAEA Action Plan on Nuclear Safety. Since capacity building has strong links with attracting and preparing the next generation of nuclear professionals, this topic was also included in the conference programme.

OBJECTIVES

The objectives of the conference were to:

- Review developments in the global status of human resource development since the 2010 international conference;
- Emphasize the role of human resources and capacity building programmes at the national and organizational level in achieving safe, secure and sustainable nuclear power programmes;
- Discuss the importance of building competence in nuclear safety and security;
- Provide a forum for information exchange on national, as well as international, policies and practices;

¹ INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Report on Capacity Building for Nuclear Safety, IAEA, Vienna (2015).

- Share key elements and best practices from the experience of Member States that are introducing, operating or expanding nuclear power programmes;
- Highlight practices and issues regarding human resource development at the organizational and national level;
- Highlight education and training programmes and practices;
- Emphasize the role of nuclear knowledge management for knowledge transfer and human resource development;
- Elaborate on the role and scope of various knowledge networks.

CONFERENCE ARRANGEMENTS

The conference was opened by IAEA Deputy Directors General D. Flory and A. Bychkov, heads of the IAEA Department of Nuclear Safety and Security and the IAEA Department of Nuclear Energy, respectively. M. Ziakova (Slovakia), acted as conference president, and P. Gowin (Germany), acted as conference rapporteur. The IAEA scientific secretaries of the conference were S. Mallick (Department of Nuclear Safety and Security) and B. Molloy (Department of Nuclear Energy). The conference was attended by high ranking officials and experts from more than sixty Member States and five international organizations. There were approximately three hundred participants.

The conference consisted of an opening plenary session followed by five topical sessions:

- Session 1: Human Resources and Capacity Building;
- Session 2: Preparing the Next Generation of Nuclear Professionals;
- Session 3: Building and Sustaining Capacity through Education and Training;
- Session 4: Knowledge Management;
- Session 5: Knowledge Networks.

The conference closed with a panel discussion and a final presentation by the conference president on insights gained, conclusions and recommendations (see the following section).

ABOUT THE PROCEEDINGS

These Proceedings document the conference objectives, arrangements and discussions, in addition to the insights gained and the conclusions and recommendations made.

The Proceedings are based on the statements made during the conference, the papers presented orally or in the interactive sessions, the panel discussions at the end of each technical session and the discussion at the concluding panel during the closing session.

The attached CD-ROM contains all conference papers and presentations, the conference programme and the list of participants. Additional material can be found at the conference web site:

<http://www-pub.iaea.org/iaeametings/46084/International-Conference-on-Human-Resource-Development>

PRESIDENT'S SUMMARY OF THE CONFERENCE

M. Ziakova²

Nuclear Regulatory Authority of the Slovak Republic

Thank you for participating in this conference and remaining until the end. I would like to begin my closing remarks by looking back four years. The 2010 conference on Human Resource Development for Introducing and Expanding Nuclear Power Programmes highlighted the importance of human resources and the need to broaden nuclear curricula, emphasized governmental and societal support, requested more cooperation in building human resources and proposed a follow-up conference to be held to monitor progress.

In response, the IAEA organized this conference we are about to conclude. It has focused on capacity building, human resource development, attracting the next generation, education and training, nuclear knowledge management and knowledge networks. I am pleased to say that the conference was very successful. It was attended by more than three hundred participants from 65 Member States and five international organizations, a very good turnout and an increase from the 2010 conference. Participation was also very broad and covered all types of countries: newcomers, countries with expanding nuclear power programmes and countries with mature nuclear programmes. It also covered all types of institutions: from industry to regulators to academia. This is clear evidence that capacity building and human resource development continue to be of high interest to many Member States.

Let us now review the work we have done in the course of the last five days.

The first insight is that the drivers for capacity building are manifold: countries with new programmes need to build up new capacity, countries with expanding programmes need to recruit additional workforce and countries with mature programmes need to ensure stable capacity and turnover. In addition, nuclear safety and security requirements provide strong drivers, and the importance of capacity building was rightly underlined in the IAEA Action Plan on Nuclear Safety.

A second insight is that in terms of nuclear activities, the world has changed since the 2010 conference. New nuclear power programmes have started in several countries, we see a continuing globalization in nuclear power, we expect

² The opinions expressed in this summary — and any recommendations made — are those of the conference president and do not necessarily represent the views of the IAEA or its Member States.

the decommissioning of additional plants in countries with phase-out policies, and the Fukushima Daiichi accident has led to additional safety enhancement.

I am pleased that an impressive number of activities in Member States that address these challenges were presented and that the IAEA has responded to these developments as well with a host of activities. In all areas we heard about this week — nuclear energy, nuclear safety and nuclear security — the IAEA has active programmes that support capacity building in Member States. New IAEA services and guidance have been developed, for example the capacity building self-assessment methodology. New networks have been established for nuclear education and training and nuclear safety and security. Other IAEA services continue to play an important role, for example the expanding catalogue of training and e-learning courses. The IAEA's Technical Cooperation programme will remain essential in this area.

Against this background, and while we will continue to need to learn from each other, we are now in a phase of implementing capacity building programmes based on proven mechanisms.

A third important insight is that capacity building programmes need to cover the full scope of the nuclear programme. They should encompass fuel, power and waste facilities; consider government, regulators, industry, academia and research; include all academic subjects needed; and cover nuclear programme management and outreach to society at large.

As a fourth insight, we heard this week that capacity building is a real need and is being addressed on many levels, all of which need to be considered:

- On the individual level, development of staff and lifelong learning are important. New multidisciplinary curricula complement the traditional engineering curricula, and training schemes supplement university education.
- On the corporate level, we see a growing culture of corporate knowledge management and recruitment programmes. The nuclear sector at present offers a very supportive environment for young generation and new employees.
- On the national level, we heard about the importance of an integrated and comprehensive national approach for capacity building. The role of governments is crucial for such an approach.
- On the global level, the globalization of the nuclear industry is mirrored by an increased internationalization of university programmes, recruitment and professional careers. A growing number of international cooperative programmes — for example, in the area of networks in nuclear education, safety and security — were presented.

As a fifth insight, I would like to comment on progress made in reducing boundaries between nuclear and non-nuclear professions. Professionals outside the nuclear sector increasingly benefit from having basic knowledge of nuclear technology, safety and security — for example, in governmental organizations, trade unions, commerce and local authorities — achieved and supported by training offers, proactive outreach and communication. Nuclear professionals in turn often have additional qualifications in non-nuclear subjects, such as law, economics, management, social sciences, communication and public administration, and we heard good examples of new or multidisciplinary curricula that support this trend. In addition to these challenges on the level of professionals, a greater general understanding by the public of nuclear technologies was deemed desirable.

From the five sessions we followed in the course of the past five days, we made the following important findings:

- Human resource needs analyses are now conducted more systematically both by mature and new nuclear programmes and sometimes even at a regional level (e.g. Europe). These analyses are extremely useful to dimension education and training efforts in the short and medium term. Human resources are the backbone of every nuclear energy programme, and a significant variety of personnel in terms of skills and training are required.
- Progress in human resource development has been made by considering both vocational training and academic education; by considering interfaces between technical, safety and security issues; by recognizing the importance of non-nuclear knowledge; and by reaching out to society.
- We heard several good examples of managing and improving the education and training pipelines. We looked at training needs analysis, the ‘systematic approach to training’ process, national programmes and international support to newcomer countries. Key conclusions were that education and training is strengthening across all levels of the skills pyramid, with good blending of theory, practical and hands-on experience.
- Strategic outreach plans are crucial for workforce development, commitment of the next generation and building acceptance of nuclear energy. Organizations need to maintain and further develop pathways ‘from education to employment’ and be ready to inspire, develop and encourage the next generation. There is also a need to engage better with the public, so that dialogue with prospective future nuclear professionals becomes more attractive.
- It is important that education and training programmes are integrated into an overall strategy for building and maintaining capacity, supported

by governments. For regulators, the management of competencies is of particular importance, and the Systematic Assessment of Regulatory Competence Needs was presented as a useful tool in that regard.

- Networks have become a proven and key mechanism to support knowledge sharing and capacity building and to foster harmonization and cooperation. A large number of successful existing and new networks at corporate, national and international levels were presented this week.
- Nuclear programmes are large scale and long term. The knowledge required for the safe, reliable and efficient operation of nuclear facilities is an asset to be properly managed. Knowledge management has to address each area of a nuclear programme — from design through construction, commissioning, operation and decommissioning or closure of nuclear facilities. Proper knowledge management contributes to meeting a company's strategic and business objectives. It is vital not only for operating, design and construction companies but also for regulatory bodies and technical support organizations, and for countries with mature nuclear programmes as well as for newcomer countries.

The IAEA is to be commended for this timely and fruitful conference, organized jointly by the Department of Nuclear Energy and the Department of Nuclear Safety and Security. The conference concluded that capacity building is a major and important step in the process of ensuring a sustainable supply of qualified human resources for safe, secure and sustainable nuclear power programmes.

The IAEA is invited to further develop its support for capacity building, to document good practices, to continue to develop tools and guidance, to provide services and assistance and to continue to facilitate international coordination and cooperation.

Member States, in turn, are invited to join existing networks and make use of available IAEA services, including the new capacity building self-assessment methodology.

There have been significant, practical developments since the 2010 conference, and we all look forward to the next occasion to continue our discussions, possibly at another follow-up conference in about four or five years from now.

My thanks go in particular to all speakers, session chairs and co-chairs and to the conference rapporteur. I also thank all participants for their valuable time, attendance and contributions.

It was your participation that made this conference a success. Thank you.

TECHNICAL SUMMARY OF THE CONFERENCE

This section contains a summary of the insights, results and lessons learned from the opening keynotes and the five technical sessions of the conference, including the panel discussions, the question and answer sessions and the closing panel during the final session of the conference.

The closing panel consisted of all session chairs and all IAEA scientific secretaries. It revisited and discussed key issues related to human resource development and capacity building. Each session chair presented his or her individual summary, which formed the basis for the conclusions and recommendations of the five sessions.

At the time of the conference, the areas of nuclear capacity building, human resource development, education and training, knowledge management and knowledge networking were very lively and active. Member States presented a wide variety of existing and new activities, projects, tools and programmes that constituted a very valuable basis for mutual learning and further progress.

The IAEA has responded to these developments and is supporting its Member States with a growing number of technical programmes in nuclear energy, safety and security. They range from technical publications, provisions of guidance, the development and dissemination of tools, and support for the establishment and operation of networks, to direct assistance and capacity building support provided through the Technical Cooperation programme.

The first introductory keynote was given jointly by B. Molloy and S. Mallick, IAEA, on Human Resource Development and Capacity Building: IAEA Perspective. The 2010 conference and the Fukushima Daiichi accident had brought attention to the importance of good and solid capacity building and human resource development, as also included and emphasized in the IAEA Action Plan on Nuclear Safety (2011).

A new methodology for capacity building self-assessment by Member States, developed by the IAEA, was presented. It defines capacity building to be “a systematic and integrated approach to develop and continuously improve the governmental, organizational and individual competencies and capabilities necessary for achieving a safe, secure and sustainable nuclear power programme.”³ Capacity building consists of four essential elements:

³ MALLICK, S., MOLLOY, B., “Capacity Building”, IAEA-CN-215/23, paper presented at Int. Conf. on Human Resource Development for Nuclear Power Programmes, Vienna, 2014.

- Education and training;
- Human resource development;
- Knowledge management;
- Knowledge networks.

Each of these elements helps in building capacities at the national, organizational and individual levels.

The self-assessment methodology addresses the following four fundamental questions:

- What is needed? (Need)
- What is available and adequate to meet the needs? (Availability)
- What is missing or what needs improvement to meet the needs? (Missing/gaps)
- What actions are needed? (Actions)

The IAEA has also offered national seminars for guidance and training in the use of the methodology. Three such three day seminars have been held, in Cameroon, Jordan and the United Arab Emirates.

The second introductory keynote was given by J. Isotalo, Finland, on capacity building experiences in her country, which has an active nuclear power programme, with plants in operation, a new build and a project to develop a long term spent fuel repository.

In October 2010, the Finnish Ministry of Employment and the Economy set up a committee to examine the long term competence needs of the nuclear energy sector, as a precondition for any further new build projects. The study was implemented by a group of experts that ensured extensive representation of the nuclear energy sector by reaching out to more than three hundred organizations. The study was presented also as a good example of the advantages of planning capacity and human resources on a national level with strong governmental support and leadership.

One of the key conclusions was that comprehensive national competence is needed by nuclear sector companies, research institutes and authorities. The training of experts and sector-specific research activities require long term investments and cooperation between domestic operators and on an international scale. In addition, public and stakeholder involvement and media contacts have benefitted from the national level approach taken. The benefits of the study, it appeared, lay not only in the results achieved but also in the momentum for cooperation the study triggered among the participating stakeholders.

Both keynotes noted that a systematic national approach to capacity building was essential and should involve all stakeholders and that evaluation and recommendations should take place at an integrated national level.

Summary of Session 1

HUMAN RESOURCES AND CAPACITY BUILDING

SCOPE

Session 1 focused on human resource development and addressed the following topics: global demand for, and supply of, human resources for the establishment and management of nuclear power programmes; feedback from relevant surveys carried out by the IAEA and other organizations; and initiatives to enhance knowledge and understanding of the relationship between nuclear safety and security.

TECHNICAL SUMMARY

Surveying human resource demand and supply trends

Good progress has been made in surveying human resource development needs and trends, in particular at the corporate or national levels and in countries with operational nuclear power programmes and with planned nuclear power programmes. Such findings were, inter alia, reported by the United States of America, France, the United Kingdom of Great Britain and Northern Ireland (UK), and Finland as countries with mature nuclear programmes and by Malaysia and Thailand as countries with planned programmes. A separate study by Areva (France/Germany) reported on human resource challenges for newcomer countries at large. These analyses are very useful in the definition of education and training efforts in the short and medium term.

An example of a successful regional and multinational survey of human resources was the comprehensive regional study on human resources demand and supply in the nuclear energy sector undertaken on a European level by the European Commission and performed under a new entity, the European Human Resources Observatory for the Nuclear Sector. The study comprised both a bottom-up analysis of predicted human resource demand and supply and a top-down analysis of human resource expectations against the European Union's Energy Roadmap 2050.

At the global level, a comprehensive and reliable scientific analysis of predicted human resource demand and supply remains to be undertaken. Findings available to date suggest that human resources and capacity building remain important issues at the global level, in particular in anticipation of accelerating

global growth in nuclear power and against a background of increasing workforce mobility.

All reports suggested that the need to monitor and survey developments had already found good acceptance, that experience in surveying methods was available, and that insights gained into national or regional programmes had always been considered worth the effort of performing the respective study and analysis. However, efforts by the IAEA to undertake such a survey were hampered by such information being considered commercially sensitive in some countries, especially those with larger programmes.

A continuing trend in global human resource development is that recruitment has become increasingly international, and work related migration in the course of individual careers has become a common phenomenon. Recruitment strategies, in particular in large multinational companies, but also in governmental organizations, have taken this into account. Recruitment for nuclear power programmes in newcomer countries in particular is international, as demonstrated, for example, by the workforce composition in the United Arab Emirates.

Curriculum development

In terms of professional qualifications, work has also continued on improving university curricula, and national approaches were presented by the Russian Federation on a leadership development programme, by China on an effort to recruit innovative talents, and by India on graduate training programmes.

Curricula are being adapted to meet changing expectations, attract good students and remain close to the demand side of human resources. The 2010 conference recommendation to broaden nuclear engineering and technology curricula to include ‘soft’ sciences, such as risk analysis, law and social sciences, seems to have found gradual support — for example, in the Russian Federation, Belgium and China — with emphasis on multidisciplinary courses, but this recommendation was not uniformly or systematically followed across all nuclear engineering courses reported to the conference. To a certain extent, this lack of implementation might be because lessons learned from the Fukushima Daiichi accident suggested that additional emphasis was also needed on the more narrow nuclear engineering and nuclear safety components of curricula. The IAEA publication *Nuclear Engineering Education: A Competence-based Approach to Curricula Development* provides updated information on curriculum development in the nuclear industry.

An important insight, though, was that in addition to the need for specialized nuclear engineers and scientists, there was a growing demand for professionals from other disciplines, such as classical engineering, biology, law, social sciences,

communication and public administration, to understand the nuclear industry in general and to have basic knowledge of nuclear technology and safety culture. The demand for this second group of professionals with nuclear knowledge was increasingly emphasized in this conference, compared with earlier conferences, and will require continued attention in national nuclear human resource development plans. In other words, nuclear knowledge is required not only by full-time nuclear professionals and engineers but also by society at large and in many sectors that are affected by, or deal with, nuclear technology only as part of their main occupation.

Reducing boundaries to other professions

Progress has been made in reducing boundaries between nuclear and non-nuclear professions. Professionals outside the nuclear sector — for example, in governmental organizations, trade unions, commerce and local authorities — increasingly benefit from having a basic knowledge of nuclear technology, safety and security, achieved and supported by training offers and proactive outreach and communication.

Nuclear professionals in turn often have additional qualifications in non-nuclear subjects, such as law, economics, management, social sciences, communication and public administration, and good examples were presented of new or multidisciplinary curricula that support this trend.

In addition to these challenges at the level of professionals, a greater general understanding by the public of nuclear technologies was deemed desirable.

Human resource planning as a national goal

Another important observation was that Member States increasingly plan human resources and capacity as an integral part of a high level national nuclear energy strategy in a top-down planning approach or on a nationally coordinated level. Examples of such structured planning and integration of human resource needs into national nuclear development plans were presented, inter alia, by China, Malaysia and Thailand.

This approach is also reflected in IAEA programmes: for example, the E-learning for Nuclear Newcomers features a module on human resource development. The issues of management and leadership development have become of critical importance for capacity building in ROSATOM (Russian Federation), and several initiatives have been launched across the nuclear industry in the Russian Federation over the last few years, including identifying and nurturing talented students in schools and universities and attracting them

into the nuclear industry, specific leadership development programmes and a career management system.

An issue of continuing relevance is the need to follow-up on education and training throughout individual professional careers, so that the training in particular of staff is not a stand-alone effort but an integral part of a lifelong learning plan. In addition, the integration of such personal development plans into organizational knowledge management programmes can ensure that the desired knowledge base of an organization can be planned also in the medium and longer term.

CONCLUSIONS AND RECOMMENDATIONS

Human resource development remains an underpinning activity for all nuclear activities, and the availability of qualified human resources is crucial, if not mandatory, for the safe and secure implementation of a nuclear power programme. Strategic planning in human resources and capacity building is a requirement. Leaders and managers must be looking ahead, anticipating change and developing new strategies. Vocational training and academic education and training are equally important. The training provider must take an integrated and comprehensive approach, combining government, industry, academia and R&D organizations; support by the IAEA is encouraged.

In addition to safety, security is important for all those working in and with any nuclear programme. There are some initiatives to develop induction programmes for nuclear security.

Despite nuclear engineers making up only a small percentage of nuclear power plant staff, it is still necessary to further develop the curriculum for them as they will not only provide nuclear technical knowledge but also be able to take on broader responsibilities, especially general management and leadership responsibilities, as they rise up through their respective organizations. Also, technicians rise up in the ranks as they gain more skills and experience.

It is important to have a demand led approach in which nuclear employers clearly articulate their needs. Because of the complicated technology, stringent operating procedures, and enhanced safety and security regimes involved in the nuclear industry compared with other power industries, a nuclear power programme needs human resources who are highly skilled.

Knowledge transfer is one of the challenges in the nuclear industry; another problem is finding young employees to replace those who are retiring. Operators, technical support organizations (TSOs), regulators and universities are facing the problem of losing experienced employees and are working on how to transfer knowledge from older workers to the young generation. To find experienced,

skilled replacement staff is difficult, thus these employers need to cooperate on an industrywide strategy to fill the generation gap.

Training systems have evolved into a more holistic approach of knowledge and know-how transfer. This evolution has involved considering both vocational training and academic education as important parts of human resource development; developing interfaces between technical, safety and security issues; recognizing the importance of fields of knowledge other than specific nuclear fields; and opening up to society's legitimate expectation to understand and master nuclear energy challenges.

Summary of Session 2

PREPARING THE NEXT GENERATION OF NUCLEAR PROFESSIONALS

SCOPE

Session 2 focused on the next generation in the nuclear sector and covered the following topics: outreach through education as a tool for developing human resources and enhancing public understanding of nuclear power, the role of women in the current and future generations of nuclear professionals, attracting young talent into nuclear power programmes, and the convergence of education and training activities — using practitioners to educate and educators to train.

TECHNICAL SUMMARY

Attracting the next generation into a career in the nuclear sector is supported by both attractive career opportunities and attractive curricula in university education. A growing number of initiatives and projects that target the next generation were reported.

Attracting the next generation through educational networks and new degrees

One example of new university course development is the European Master in Innovation in Nuclear Energy. It was established through cooperation between several European universities and through a partnership between academia and industry. The course also illustrates how governmental support in terms of providing sustainable frameworks can facilitate such innovative courses, as the course can readily use the established European Credit Transfer and Accumulation System as a basis for transparent credit accumulation, as is also the practice for the existing European Master of Science in Nuclear Engineering offered by the European Nuclear Education Network.

These European educational networks, as well as networks that support education and training on a national level (e.g. the Belgian Nuclear Higher Education Network) are also good examples of how pooling and sharing educational and institutional resources can facilitate or even enable new, attractive and high quality nuclear education and training. Session 5 also supported this finding.

As part of the national strategic development plan in the Russian Federation, the National Research Nuclear University (MEPhI) has defined its own development objectives as a leading nuclear education supplier, with a strong emphasis on the internationalization of students and teachers, on educational networking and on building close alliances with the nuclear industry.

Educational networks also play an important role in increasing transparency and comparability, in terms of course content, for the mutual recognition of credits and degrees and for the quality assurance of courses offered under the network arrangements.

The next generation in local workforce planning

Attracting the next generation is not limited to established career paths in nuclear science and engineering within the nuclear sector. Strong and good interactions with local communities and organizations, trust, mutual understanding and cooperative sustainable relationships with the local and national labour markets are also crucial for a successful nuclear new build project, as was reported and illustrated by EDF Energy's new build project Hinkley Point C in the UK. EDF Energy, as a large employer of nuclear professionals and of local labour for construction and operation, places high emphasis on building such sustainable relationships to meet the predicted high workforce demand.

EDF Energy's education programme Inspire encompasses primary education to higher education, professional career choice, and employment in the nuclear sector, including civil engineering and supporting professions. Through an employment brokerage scheme, local labour employment is being supported, with explicit consideration of opportunities for women, minorities, and people with disabilities.

Recruitment and knowledge transfer to the next generation

The IAEA supports organizations in managing intergenerational knowledge transfer, which remains an important driver for education and training programmes aimed at the young generation in corporate and organizational contexts. Bridge of Generations was chosen as the title of the Russian JSC Atomenergomash's project to mitigate loss of corporate knowledge and ensure continuity between today's workforce and the next and future generations in terms of skills, capacity and knowledge. Two pilot projects have been completed using the IAEA methodology on knowledge loss risk management.

Attracting the next generation is essential in the context of nuclear safety and security, including for regulators and related TSOs. As an example, the Korea Institute of Nuclear Safety in the context of its 2020 vision explicitly recognizes

the importance of developing highly trained employees, creating development opportunities, recruiting and retaining employees and building a high performance learning organization. The integration of the corporate competence based human resource management and the individual career development programmes illustrates the benefits of addressing organizational and individual capacity building objectives in an integrated way.

Recruitment programmes that seek to attract qualified new talent into the nuclear sector apparently are a standard component of human resource departments in nuclear organizations. Such programmes are used by smaller national nuclear utilities, such as Slovenské Elektrárne (Slovakia); large global multinationals, such as Areva (France); the power industry and regulators; the private sector; and governmental bodies.

Compared with other industries that can have, depending on national contexts, very variable demand for new recruitment and next generation interests, the nuclear sector offers a comparatively stable and good environment for new employees and corporate strategies that are supportive of the young generation and new employees.

Recruitment programmes are of particular importance for countries with new or planned nuclear programmes, notably for the leading nuclear energy programme implementing organization and new nuclear power operating organizations. This importance is reflected in human resources being one of the 19 infrastructure issues in the IAEA's Milestones approach to the development of new nuclear energy programmes. For these programmes, a careful analysis of the necessary staffing mix and lead times is essential to ensure that the right number of the right people are in the right place at the right time.

CONCLUSIONS AND RECOMMENDATIONS

Long term outreach plans for nuclear power programmes are crucial to ensuring that existing and new nuclear programmes will have the necessary human resources, that a competent workforce can be developed and that the next generation remains committed and aware of the need for nuclear applications. Future generations are likely to have work–life balance expectations that differ from those of the current generation: a development that would also need to be considered.

Outreach plans need to be developed and implemented to achieve business objectives and not just as a public relations activity to gain public acceptance. Naturally, such plans would be part of the workforce planning process, in which a competent workforce is developed through education and skills development. To achieve such a goal, experience shows that it is critical to establish partnerships

with educational institutions and local organizations. There may be a need to redefine ‘nuclear outreach’, provide a new vision of nuclear application capabilities and better describe to the general public what nuclear applications could look like, so that dialogue with future nuclear professionals becomes more attractive.

Many discussions addressed the staffing of nuclear facilities. The question of how to ensure that there would be the right people at the right time in the right place and with the right competence was repeatedly asked. Other questions raised were how to prepare the next generation, what competencies would be required, how many professionals would be optimum and how to avoid erroneous predictions.

The role of women in current and future generations of nuclear professionals remains important, and participants reported a need for more attention to be paid to this topic in future activities. Practical examples of women in the nuclear industry should be provided, and best practices for the recruitment and retention of women should be shared and discussed among Member States.

The need for national and international academic courses was stressed, and customized training was encouraged. Realistic training needs are to be incorporated into the organization’s long term business plan at an early stage. Partnerships with universities and schools are very beneficial in ensuring the sustainability and quality of training. Internships and engagement in long term projects are a useful method to retain professionals after training. Mentorship and certification are necessary for several relevant functions or positions within the nuclear organization — for example, for nuclear power plant control room operators.

Many nuclear organizations are struggling with the risk of knowledge loss, which needs to be monitored in the coming years; areas of particular concern are a lack of experience in managing the retention and transfer of knowledge and the low motivation of knowledge owners for the preparation of their replacements. Some organizations have started their own programmes to mitigate the loss of critical knowledge; their continuation was strongly encouraged. It might be beneficial if the nuclear industry could select from a larger pool of potential employees. This scenario could be achieved by initiating comprehensive human resource development programmes that span a wide spectrum of topics and venues — from primary education to PhD programmes.

Participants encouraged the IAEA to continue to work with Member States in the area of human resource development and workforce planning.

Summary of Session 3

BUILDING AND SUSTAINING CAPACITY THROUGH EDUCATION AND TRAINING

SCOPE

Session 3 focused on education and training and covered the following topics: education and training for specific target groups or organizations; education and training — national initiatives, programmes and challenges; innovative tools and techniques for education and training; approaches to the assessment of training needs — lessons learned; and competency framework — application of a uniform model.

TECHNICAL SUMMARY

Education and training remain of prime importance in the nuclear area:

- University education remains the backbone of building scientific and technical in-depth knowledge and qualified professionals. The educational trends reported at the conference included new multidisciplinary curricula and the networking of institutions.
- Training increasingly complements the learning base in the nuclear field and is playing an ever more important role:
 - Professionals from non-nuclear disciplines can be included in the nuclear workforce through qualified training in nuclear areas.
 - Nuclear professionals benefit from training as part of their individual career development.
 - Organizations (governmental, R&D and commercial) use large training programmes as part of their corporate knowledge development strategies and increasingly offer such training to other organizations or countries.

Education and training at the national level

Education and training are core components of national competence planning, particularly in countries that have high level strategic national nuclear development plans in place. For example, the Korea Atomic Energy Research Institute reported a trend of more systematic planning of education and training activities and emphasized the importance of continued government commitment

to nuclear education and training. Integrated competence based education and training for nuclear energy programme implementing organizations, operators, regulators and TSOs was considered important, and international cooperation in education and training was considered extremely beneficial to the sharing of lessons learned and the development of effective and efficient national capacity building plans.

For newcomer countries, a strategic and phased approach to address human resource development was generally deemed to have become good practice. Saudi Arabia, for example, described its human capability building programme as having started with an analysis of expected supply and demand and a gap analysis. These analyses were followed by the development and adoption of a human capacity building road map with detailed role descriptions and actions, the modelling of workforce needs over time and an analysis of local human resource development capacities and necessary outreach to international partners. Another example of national human resource development was presented by South Africa, in support of the planned new build in the 2010–2030 time frame.

Newcomer countries often need not only to rely on national education and training but also to seek and benefit from international cooperation. The joint work of Hungary and Viet Nam provides a good example of bilateral cooperation between a newcomer country and a mature country. On the basis of an agreement between the two countries, nuclear training for 160 Vietnamese university lecturers was provided in 2012 and 2013 in Hungary. This bilateral cooperation in turn supports the cooperation of Viet Nam and the Russian Federation in the construction of the new nuclear power plants themselves.

A national approach to human resource development is also being pursued by countries with mature nuclear programmes. Japan established the Japan Nuclear Human Resource Development Network in 2010 as a framework for nuclear human resource development throughout Japan. Under the network, products such as textbooks and e-learning tools are being developed, as well as higher level analyses, such as a strategic road map and database of human resource development in Japan for newcomer countries.

Technical specialist training needs in nuclear organizations can also be outsourced and provided by specialized organizations, as reported for example by the UK for staff training at the Sellafield fuel reprocessing plant. Efforts are under way to expand the training to also support future nuclear power plant workforce needs. The UK has also set up the National Skills Academy for Nuclear to facilitate access to and implementation of training in support of the national nuclear programme, and a group of British universities established the Nuclear Technology Education Consortium in support of more integrated higher university education. A national integrated approach towards human resource development is also being pursued in the US nuclear industry: the Nuclear Power

Institute (Texas) has set up several programmes to support outreach, training, education and recruitment in partnership with stakeholders from government, academia and schools, industry and local communities.

A special driver for human resource development, education and training is the need to also ensure a qualified workforce for the decommissioning of nuclear facilities, be it at the end of their planned lifetime or as part of phase-out policies. In addition, the staffing of spent fuel and waste management facilities is an important driver.

Support for nuclear education and training has also become an important pillar of vendors' efforts in international markets in their relationship building with, and programme support for, potential customers. In a special side event on nuclear education and training in France, it was reported that a central entity, the International Institute of Nuclear Energy had been set up as France's bilateral relations institution in the field of nuclear energy education and training, with the objectives of coordinating education and training efforts, as well as supporting the export of French nuclear technology. Other major vendors (e.g. the Russian Federation and the Republic of Korea) pursue similar approaches to support export through human resource development and education and training programmes.

A study from Turkey, as a newcomer country, yielded important insights for education and training. The study concluded that more national nuclear educational institutions would be desirable. The study also concluded that more psychologists, sociologists, political scientists and lawyers should study nuclear power programmes.

Education and training at the corporate level

Education and training, knowledge management and capacity building systems and strategies have been widely adopted at the corporate level and have become more and more a standard element of corporate planning, as was illustrated in several presentations.

Considerations at EDF (France) are driven mainly by workforce ageing and turnover requirements since a very high percentage of nuclear power plant personnel in France are at or close to retirement age. EDF decided in 2010 to implement a new competency management model, a French adaptation of the systematic approach to training, which is now established in all EDF nuclear power plants.

These trends to develop and implement enhanced training in nuclear organizations is not only visible in the large companies described above but also reflected in smaller utilities, for example Slovenksé Elektrárne (Slovakia), which has also enhanced its systematic approach to training process.

TSOs and regulators introduce human resource development and training schemes on a systematic basis to ensure that staff can contribute to the organization's goals on a reliable and stable level, as the related nuclear safety considerations make competence based decisions and decision making support mandatory. For example, the Belgian TSO Bel V, established to support the Belgian regulator, introduced a human resource management process as part of its International Organization for Standardization 9001:2008 certified integrated management system and utilized the IAEA's Systematic Assessment of Regulatory Competence Needs (SARCoN) tool for regulatory bodies of nuclear facilities. The Pakistan Nuclear Regulatory Authority also reported using a strategic approach to develop and implement its training programmes.

The SARCoN tool is being used not only by individual regulators but also by groups of regulators. Under the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies, the project CReAN (Competences of Regulators in the Area of Nuclear Safety) has been established to develop a harmonized competence building system in the region through the use of the SARCoN tool. The project identified a model of staffing for a typical Ibero-American regulatory body and collated the knowledge resources and training facilities available in the region.

Training programmes offered or used by corporations have reached a high degree of specialization, and a wide variety of specialized training modules and course content has been developed. The training demands of the nuclear sector might even grow in the future, as indicated by expansion plans, the demand for new staff in newcomer countries and the identification of new training needs (e.g. specialized training for nuclear executives).

Education and training for specific topics

In addition to the education and training programmes that are primarily driven by national or organizational development considerations, there are other training programmes driven by thematic considerations — for example, nuclear security, a theme of relevance across organizations and countries. The importance of competency in nuclear security was emphasized at the 2014 Nuclear Security Summit and by the IAEA General Conference. The IAEA's programme on nuclear security offers a broad range of guidance and training publications and materials. Most prominently, the International Nuclear Security Education Network (INSEN) was established in 2010 under the IAEA Nuclear Security Programme. Examples of such topic driven activities are the launch of the WINS Academy by the World Institute for Nuclear Security in 2014 and the systematic approach to training for specialists in physical protection, accounting and control of nuclear materials in Ukraine.

Human resource development and training activities are also driven by nuclear safety considerations, in particular in light of the Fukushima Daiichi accident. For example, Japan reported on the establishment of a new Human Resource Development Centre under the Nuclear Regulation Authority of Japan in 2014, which also provides contributions to the IAEA–Asian Nuclear Safety Network activities. At the regional level, the European Commission project EAGLE, started in 2013, reviews and develops communication strategies targeting the general public on the subject of ionizing radiation, including communication on the Fukushima Daiichi accident.

Advances in information and communication technology

Advances in information and communication technology continue to open up new opportunities for innovative and effective education and training programmes. Training in particular, but also university based education programmes, use Internet based learning, remote access to training material, long distance tutorials and other technology based approaches to increase the accessibility of the courses, reduce cost, increase flexibility and attract students.

IAEA support for education and training

The IAEA is supporting education and training through several programmes. Although the IAEA is not primarily an educational organization, it provides important support to education and training activities in Member States in several areas, including nuclear safety and security, nuclear energy, safeguards and non-proliferation, and nuclear applications by, for example, creating e-learning materials on specialist topics not available commercially.

CONCLUSIONS AND RECOMMENDATIONS

The importance of a competence based approach to education and training was highlighted in various examples from Member States. Also highlighted as important were the application of the systematic approach to training, in general, and appropriate training needs analysis, in particular. Such emphasis exemplifies the need for strong engagement with stakeholders. Enhanced safety competence is now well established, and security competence is becoming recognized as an integral element of education and training programmes. Additionally, the importance of competencies for the regulator was highlighted.

With many good examples of national and international education and training programmes, it is evident that our community is well prepared in terms

of the technical implementation, but is this implementation ‘smart’ in meeting workforce needs? The integration of education and training into a strategic capacity building and human resource development plan will help to meet such needs, and governments have a role to play in supporting workforce development programmes.

Support for nuclear newcomers and for countries that are currently considering nuclear energy was evident throughout this session, but an underlying concern was the so-called brain drain (the loss of well-educated and trained personnel to other organizations or even countries) and how this phenomenon could be addressed.

Another concern in some cases was the availability of suitably qualified and experienced educators and trainers.

The education and training sessions demonstrated a renewed commitment, continued innovation in methodologies and an emphasis on network strengthening, nationally and internationally, to develop the future nuclear workforce. However, more effort is needed to enthuse the younger generations to think of the nuclear sector as holding an exciting and challenging career path that goes beyond reactor physics and thermal hydraulics.

Summary of Session 4

KNOWLEDGE MANAGEMENT

SCOPE

Session 4 focused on knowledge management and covered the following topics: knowledge management across the life cycle (knowledge generation, capture, validation, transfer and preservation); knowledge management integration into day to day activities; assessment of knowledge management maturity for Member States embarking on or expanding nuclear power programmes; knowledge management implementation issues for different nuclear organizations; and capturing and preserving knowledge, with an emphasis on the needs of newcomer countries.

TECHNICAL SUMMARY

Knowledge management is distinct from individual education and training activities or human resource management programmes in that it is based on the integration and joint development of three components:

- People (human resources);
- (Business) processes;
- (Information and communication) technology.

By combining features from each corner of this triangle, capacity building can be understood, described and promoted through an integrated knowledge management approach.

National and corporate knowledge management

Nuclear knowledge, as it is created through significant investment by society or companies over long periods of time, constitutes an important and valuable asset that should be managed properly and on a sufficiently long timescale.

Knowledge management, as a methodology, can be applied at many levels, including the nuclear sector, national planning and corporate business levels. Today, knowledge management has become an established discipline outside the

nuclear sector and many tools and approaches are readily available for use in nuclear contexts.

Corporate knowledge management programmes were reported to be in place in many nuclear organizations to support organizational or business objectives. The link between knowledge management and business objectives and the understanding that human resources constitute, from a business point of view, both investment and capital, were raised in several contexts.

ROSATOM, which has more than 250 000 employees, has adopted an internal knowledge management system (ROSATOM Knowledge Management) that governs R&D activities and manages technical content, including important intellectual property rights, and technical communities. The system is closely connected to the company's business strategy. Leadership training, as part of the corporate strategy, was reported as an important component. The leadership training not only supports corporate knowledge building but also serves as a visible incentive for all staff to engage in training schemes.

The Finnish Fortum, an expert organization, is using knowledge management to maintain and build organizational knowledge, with defined business objectives as the primary driver. The combination of formal knowledge management processes and informal knowledge management embedded in the daily work of experts and managers was named as a success factor.

The US Palo Verde nuclear power plant has developed and successfully integrated a knowledge management approach into its strategic human capital management systems. This approach integrates knowledge management strategies into organizational assessments and business planning, workforce analytics, talent selection and development, and organizational key performance indicators.

Knowledge management is used by commercial and non-commercial organizations, such as regulators. An example is the US Nuclear Regulatory Commission, which has had a comprehensive corporate knowledge management system in place since 2006. The Nuclear Regulatory Commission considered that the success of that programme was largely due to having a formal policy that established governance and roles and responsibilities and to having strong executive leadership support. Knowledge mapping was reported to be a useful tool at the corporate level, one that was widely used also outside the nuclear community in support of business processes and individual work performance.

Preservation of knowledge

The preservation of knowledge continues to be an important part of knowledge management programmes. There is a potential risk of knowledge loss

as many specialists have already retired or are due to retire shortly, but nuclear power programmes and projects can last several decades and span a long time.

At the international level, knowledge preservation projects are being implemented for fast reactors and for water cooled, water moderated power reactors. Preserving knowledge from past nuclear accidents is also considered important. In light of the Fukushima Daiichi nuclear accident, it is recognized that valuable data and lessons learned should be effectively shared to prevent similar accidents from happening again.

Knowledge loss is also a concern at the corporate level. The Czech CEZ established its knowledge management programme in 2006 and is implementing a knowledge loss risk assessment and management scheme for both nuclear power plants in operation. A key success factor was reported to be the coordination of the scheme with other existing business processes in an integrated corporate management approach.

Knowledge management and university programmes

Higher education university programmes as well as training schemes can benefit from applying knowledge management tools and techniques. In addition, knowledge management has itself become a subject in university and training courses that can be taught through established course modules, as reported and offered by Spain and Austria, for example.

Knowledge management, with its focus on combining people, processes and technology, is particularly active in using advanced information and communication technology tools, as demonstrated, for example, in a new IAEA proposal to develop a Virtual Nuclear Management University. The university would be an IAEA facilitated collaboration with universities to agree on standardized curriculum requirements for them to provide master's degree programmes in nuclear management to target managers working in the nuclear sector. Another example is the Cyber Learning Platform for Nuclear Education and Training.

CONCLUSIONS AND RECOMMENDATIONS

Experience from designers, operators, regulators and commercial companies, both small and large, clearly shows the extent to which nuclear organizations depend on knowledge. As a result, it was recognized that knowledge, and nuclear knowledge in particular, is an asset to be highly valued by all individuals and organizations in the nuclear sector. In other words, knowledge

should be considered a key asset of strategic value, needed to meet the business objectives of nuclear organizations.

This recommendation also concerns governments, as nuclear knowledge is also an asset at a national level. As a consequence, from a national point of view, nuclear knowledge management should encompass the full life cycle — from the beginning, to design, to construction and commissioning, to operation and decommissioning — and should be applied to all nuclear facilities, those at the front end, in energy production, and those at the back end.

In recent years, knowledge management programmes have made good progress. Continued emphasis is needed on the inclusion of all educational stakeholders (i.e. universities, training institutions and programmes for vocational training) and on-the-job training.

Knowledge management is also of high importance because of the special emphasis on the interconnection between people and technology and the possible contribution knowledge management can make to the safe, reliable and effective operation of nuclear facilities.

An important reason to establish knowledge management programmes is that such programmes can help to avoid knowledge loss, a challenge many organizations are still facing.

Summary of Session 5

KNOWLEDGE NETWORKS

SCOPE

Session 5 focused on knowledge networks and covered the following topics: comparative advantages of nuclear knowledge networks — a way forward; international initiatives, programmes and challenges in relation to knowledge networks; experience related to global, regional and topical networks; and methods and tools to build up sustainable knowledge networks.

TECHNICAL SUMMARY

Knowledge networks are a combination of two approaches: the consideration of knowledge (i.e. the consideration of people, processes and technology in an integrated manner) and the use of networks as a mechanism.

Knowledge networks can be used at several levels to connect entities such as individuals, organizations or countries. They are a very effective tool to support mutual learning and knowledge exchange as they provide a central mechanism for the interactions of participating network partners. Across the conference sessions, networking and knowledge networks were recommended as very successful mechanisms.

Effective knowledge networks can connect:

- Different entities that are united by interest in a shared topic, such as the use of a specific management approach in otherwise different organizations;
- Similar entities that exist in different contexts, such as regulators in different countries.

Examples of the former type in the area of nuclear security are INSEN, established in 2010, and the International Network for Nuclear Security Training and Support Centres, established in 2012. These knowledge networks connect different types of organizations that are united by a common objective in nuclear security education and training.

Another example of a knowledge network is the European Technical Safety Organisations Network, which itself is an important part of regional and global nuclear safety and security networks. The European Technical Safety Organisations Network connects TSOs from different countries and aims to

develop and promote best practices in nuclear safety assessment. Networking allows the sharing of information and knowledge among the expert community and supports effective collaboration.

Knowledge networks can, and often should, be supported by information and communication technology, such as web portals or other Internet based platforms or mechanisms, as demonstrated by the Bulgarian nuclear regulatory portal, one of many examples of the use of technology to support knowledge sharing.

The IAEA-supported nuclear education and training networks — the Asian Network for Education in Nuclear Technology, the African Network for Education in Nuclear Science and Technology and the Latin American Network for Education in Nuclear Technology — are good examples of effective IAEA support for Member States in the area of knowledge networking.

The success of this networking approach has already been demonstrated by the European Nuclear Education Network, which has existed since 2003. In addition to offering its best known product, the European Master of Science in Nuclear Engineering, the European Nuclear Education Network effectively serves as a knowledge network for the sharing of data, information and knowledge about nuclear education and training among European educational institutions.

CONCLUSIONS AND RECOMMENDATIONS

Knowledge networks are an effective mechanism for capacity building and for strengthening the national nuclear energy, safety and security infrastructure. Such networks can respond globally to any need in the safety and security area and have been instrumental in promoting nuclear safety and security standards and related IAEA peer review and advisory missions.

Knowledge networks can also support human resource development through education and training. They form a good basis for providing scientific support, promoting the convergence of practices and developing national nuclear infrastructure expertise. Existing networks have played essential roles in facilitating capacity building and the sharing of knowledge and expertise.

It is important to further develop the link between global and regional knowledge networks and to work towards the further coordination and harmonization of knowledge management approaches with network participants.

The scope and membership of the networks should be broadened, and participants encouraged the IAEA to consider further strengthening its support both for global and regional networks, noting also their importance for newcomers in connecting to global and regional workforce supply chains. Stable financing and continued monitoring of network performance were additional recommendations.

OPENING STATEMENT

D. Flory

International Atomic Energy Agency

I am pleased to welcome you to this International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity.

This conference will continue the tradition established by preceding conferences in this area, in particular the one held in Abu Dhabi in 2010. Capacity building is a major first step in the process of ensuring suitably qualified human resources that are ready to assume responsibility for a safe, secure and sustainable nuclear power programme. The importance of capacity building was underlined in the IAEA Action Plan on Nuclear Safety (2011), where one of the actions calls upon Member States “to strengthen, develop, maintain and implement their capacity building programs”. Also, the critical role of human resources and capacity building in developing and maintaining nuclear infrastructure was reiterated by subsequent International Experts’ Meetings related to the IAEA Action Plan on Nuclear Safety. Similarly, IAEA Nuclear Security Plans stress the importance of nuclear security education and training for Member State capacity building and outline relevant activities for the future. This conference will focus on global challenges of capacity building, human resource development, education and training, nuclear knowledge management and establishing or maintaining knowledge networks.

Let me speak for a few moments on the action itself. Capacity building, as mentioned in the Action Plan on Nuclear Safety, is directed at Member States with nuclear programmes and at those that are planning to embark on them. However, it is not a new activity either in Member States or in the Agency. The Agency through its education and training, human resource development, knowledge management and knowledge network activities has been focusing on this for many years. We have prepared and delivered comprehensive training packages and human resource development programmes in Member States for building capacity in all areas related to nuclear power programmes.

Today, I would also like to report very briefly on our activities on this important action related to each of the major sessions of this conference.

NUCLEAR SAFETY

On the safety side, we have prepared a Strategic Approach to Education and Training in Nuclear Safety 2013–2020, which is in line with and supports the IAEA Action Plan on Nuclear Safety. I would like to mention our activities specifically related to supporting the efforts of Member States to strengthen the technical and managerial competencies of their regulatory bodies:

- (a) The development of guidelines for the Systematic Assessment of Regulatory Competence Needs (SARCoN) for identifying gaps in the competencies of regulatory bodies to perform their functions and in their related training needs. A software tool to facilitate the application of SARCoN has been made available to Member States.
- (b) The publication of a Safety Report (No. 79) on Managing Regulatory Body Competence.
- (c) The ongoing revisions of the textbook and workbook on Regulatory Control of Nuclear Power Plants and the Basic Professional Training Course on Nuclear Safety.
- (d) The development of packages of exemplary training material, based on the IAEA safety standards and practical case studies, to support workshops and expert missions tailored to the needs of regulatory bodies of countries embarking on nuclear power programmes.
- (e) The new safety services called the Education and Training Review Service (ETRES) and the Safety Assessment Advisory Programme (SAAP), which utilizes the Safety Assessment Education and Training (SAET) Programme.

RADIATION, TRANSPORT AND WASTE SAFETY

In the areas of radiation, transport and waste safety, we already have a very well established Strategic Approach to Education and Training in Radiation, Transport and Waste Safety 2011–2020, which calls upon Member States to develop national strategies for education and training in this area. The related Education and Training Appraisal (EduTA) service has been already provided to 14 IAEA Member States.

EMERGENCY PREPAREDNESS AND RESPONSE

Here I would also like to mention another of our achievements linked to our Response and Assistance Network (RANET): the designation of the IAEA

RANET Capacity Building Centre. This project officially commenced in December 2012, following the signing of the Practical Arrangements between the IAEA and the Ministry of Foreign Affairs of Japan under the Memorandum of Cooperation between the IAEA and the Fukushima Prefecture. Since then, a number of workshops has been conducted in this centre.

NUCLEAR SECURITY

Our nuclear security education and training programmes are equally well developed. As in safety, human resource development is critical for States to develop, sustain and advance their national nuclear security regimes. We work hard to make sure that people have the right knowledge and capabilities. Our nuclear security education and training activities are thus geared towards a diverse audience, from nuclear regulators, facility operators and customs officers to police and border forces, academic instructors, students and staff at research institutions.

In pursuit of this goal, the IAEA has made several important advances in its nuclear security education and training programmes, including:

- (a) The development and implementation of a comprehensive training programme, offered to Member States in a variety of disciplines, covering all aspects of nuclear security. Between 2010 and 2014, we have implemented more than three hundred national, regional and international training courses based on documents and recommendations in the IAEA Nuclear Security Series. These documents have been developed in conjunction with our Member States, and as such represent internationally accepted standards.
- (b) The development of a model master of science academic curriculum based on IAEA Nuclear Security Series No. 12, entitled Educational Programme in Nuclear Security, jointly with a large group of international experts, and the creation in 2010 of the International Nuclear Security Education Network (INSEN). A growing number of universities and departments offer new programmes or courses in nuclear security, using the materials developed by INSEN experts and institutions, including a consortium of European Union universities, offering a pilot master of science degree programme, which was inaugurated by the Director General last year. Other universities are following this lead.
- (c) The establishment of the International Network for Nuclear Security Training and Support Centres (NSSC Network), which helps to ensure sustainable nuclear security by acting as a resource base to facilitate national training and providing technical support services for life cycle

equipment management and scientific support services for the detection of and response to nuclear security events. Some fifty States have established such centres or have plans to do so. The IAEA coordinates the activities of the NSSC Network with a view to strengthening nuclear security training and support services as a cornerstone of national, regional and international capacity building activities.

The value of this work and the importance of capacity building for nuclear security was recognized in the Ministerial Declaration adopted at the International Conference on Nuclear Security that we organized last year in Vienna, as well as by our Member States through IAEA General Conference resolutions and at other international fora, such as the 2014 Nuclear Security Summit in The Hague.

KNOWLEDGE NETWORKS

Finally, we have active knowledge networks under the GNSSN, our Global Nuclear Safety and Security Network. These networks include global networks such as the International Regulatory Network (RegNet), the Technical and Scientific Support Organization Forum (TSOF) and the Global Safety Assessment Network (GSAN). It includes regional networks such as the Asian Nuclear Safety Network (ANSN), the Arab Network of Nuclear Regulators (ANNuR), the Forum of Nuclear Regulatory Bodies in Africa (FNRBA) and the Ibero-American Forum of Radiological and Nuclear Regulatory Agencies (FORO), and also thematic networks such as the Regulatory Cooperation Forum (RCF), the forum for senior regulators of CANDU reactors, the WWER Regulators' Forum and the Control of Sources Network (CSN).

The Global Nuclear Safety and Security Network (GNSSN) is an inclusive concept that links, complements and brings together all existing networks and initiatives and is recognized as instrumental in harmonizing approaches and adopting best practices to achieve sustainable nuclear safety and security infrastructures. Since 2011, over three hundred capacity building activities were implemented under the GNSSN framework, gathering more than two thousand experts from 109 of our Member States. The impact in Member States with nuclear power programmes, and in those embarking on one, should be significant. We also have activities geared towards the management of safety knowledge. The capacity building concept helps to bring all these activities under one umbrella in a coordinated and integrated manner.

To conclude, I would like to thank all the delegates for their participation in this conference and urge you to participate actively in its deliberation. I wish you a very successful conference. Thank you.

OPENING STATEMENT

H. Alkaabi⁴

Permanent Mission
of the United Arab Emirates to the IAEA

[In his opening remarks, HE Mr. Alkaabi, United Arab Emirates (UAE), who had also served as conference president at the 2010 IAEA International Conference on Human Resource Development for Introducing and Expanding Nuclear Power Programmes, commented on the outcomes of that conference.]

Your excellences, distinguished guests, ladies and gentlemen,

I have the pleasure of addressing you today on a topic that is very critical for the global nuclear power sector: the development of human resources.

For both nuclear newcomers and countries with existing nuclear power programmes, national capacity building constitutes the main principle to ensuring success and sustainability in the long run. The education and training of personnel in the industry and related government entities is an aspect of the nuclear power sector that needs to be given top priority.

The UAE nuclear power policy and approach gave special emphasis to human resource development as an essential element of the programme. Since then, human resource development has been our focus in the UAE nuclear energy programme, an advanced nuclear newcomer with two reactors under construction and more planned.

The availability of skilled nuclear professionals is fundamental for the scale-up of a growing nuclear industry worldwide. Yet today, we are faced with an ageing nuclear expert workforce, and we may see soon an overall shortage of these professionals in the future. This issue needs to be addressed so we can ensure that all nuclear power programmes globally are developed, managed and operated in a safe and sound manner.

Of course, in many countries, different stakeholders are taking important measures to fill this gap and have made great efforts to implement relevant training programmes. Still, additional efforts must be pursued.

To address this issue, I had the honour to preside over the first major International Conference on Human Resource Development for Introducing and Expanding Nuclear Power Programmes that was convened in 2010 in Abu Dhabi.

⁴ The opinions expressed in this summary — and any recommendations made — are those of the named speaker and do not necessarily represent the views of the IAEA or its Member States.

The conference focused on the concern surrounding the potential lack of a skilled workforce in the nuclear energy sector in the coming decades. Today, and four years later, I would like to recall the important issues raised at that conference and its outcomes.

I would first of all like to call to your attention the visible increasing demand for clean and reliable energy at the global level over the past decades. The nuclear industry has witnessed a number of countries taking concrete steps towards establishing their own nuclear power programmes.

These nuclear newcomers, such as my country, the United Arab Emirates, or countries that have planned and are currently setting the stage for expanding their nuclear power programme, are looking to experienced nuclear countries to develop their strategies as well as to understand the challenges in building up the crucial pillars of a successful programme. Human resource development is one of these key areas.

This is not only relevant for nuclear newcomers, however. Other countries are adding new reactors to their existing plants. The 2010 conference highlighted the plans of countries such as China, India, France, Japan, the Russian Federation and the United States of America, which at that time were planning a robust expansion in their nuclear power fleet.

While there is no doubt surrounding the demand for nuclear energy, questions lie within how to acquire a proportionately high competency workforce to design, build, license and operate these plants. We must take into account that for each nuclear power plant that begins operation, nuclear experts must be at hand for the span of one hundred years. This takes into account the years from the programme's initial inception all the way through to its decommissioning.

We are proud to note that the industry's current professional workforce consists of renowned experts that have built the foundation for nuclear power over the past fifty years. Yet these experts are now approaching retirement age. Unfortunately, in numerous countries, the number of students that are being educated in nuclear and other relevant fields may not be sufficient in compensating this foreseeable loss in the available workforce.

This challenge is relevant in various phases of nuclear power plant development. For countries that are embarking on new programmes, it is important that they independently seek to establish a domestic expertise and skills base.

They should not, for example, rely exclusively on the human resource support from their technology supplier as a long term strategy, and here I would like to mention the innovative model the UAE is utilizing in building its workforce on international experience while at the same time developing local expertise through multiple integrated initiatives.

For States with plans to expand their existing programmes, this consideration should first be met with the assurance that they are able to scale up to meet the demand of a larger skilled workforce in the necessary time frame.

Finally, for countries that will be supplying nuclear technology, it is important that the country maintains a national human resource base and, at the same time, is able to transfer knowledge and training alongside the technology it exports.

At the 2010 conference, these important issues were discussed at length, with an array of countries outlining their challenges as such. Experts, scientists and officials from 62 States participated by sharing their relevant experiences and concerns.

The conference concluded with three principal issues:

- First, participants highlighted the need to expand nuclear engineering and technology education so as to include ‘soft’ sciences like risk analysis, law and social sciences. A number of new approaches were presented in light of how countries were already doing this. The United States of America implemented the Nuclear Power Institute partnership to integrate colleges and universities with the nuclear industry for a large range of degrees in the nuclear field. Japan likewise initiated a nuclear socioengineering programme, while the UAE joined with US universities and national laboratories to integrate education on nuclear policies and areas such as safety, security and non-proliferation. While discussing strategies that could attract youth to pursue a career in the nuclear field, the 2010 conference underscored the importance of employing women in the sector.
- A second conclusion from the conference was that strong governmental and societal support are two essential characteristics that are absolutely necessary for achieving a successful programme. The roles of government, educational facilities, industry and international organizations were determined in light of addressing the human resource development challenge. Considering the long life of any nuclear power initiative, stable national policies are important for maintaining the integrity and functionality of the programme. Society as well needs to be involved and educated on overarching aspects of nuclear power in order to ensure that a programme develops and runs smoothly.
- Finally, it was clear from the 2010 conference that there was an increasing request for more cooperation at the local, national and international levels in the area of building human resources for a nuclear power programme. Extensive networking was deemed an important tool for providing necessary data and educational courses. It was noted that through collaboration, potential ‘isolationist’ trends would be avoided. Additionally,

collective knowledge sharing would be beneficial for nuclear newcomers, as best existing practices would be examined. Nuclear countries could also take advantage of new methods being conjured and piloted.

To conclude, four years from the Abu Dhabi conference I can only highlight the importance of having a robust and competent nuclear workforce to guarantee that nuclear programmes meet the highest safety and security standards. Capacity building is at the core of any programme's efficient operation and long term sustainability. We collectively have to pay due attention to this issue and utilize concrete strategies on how to address it. The 2010 conference was successful in identifying the challenges of all sectors involved in nuclear power programmes with regard to addressing human resource development. It also effectively reported on several new initiatives that are beneficial to consider in this thematic area.

Today's conference as the second conference on human resource development should review progress made in light of the outcomes from the 2010 conference over the past four years. I hope our deliberations herein will be fruitful and add extensively to the establishment of indispensable capacity building in the nuclear sector.

I thank you for your attention.

CLOSING STATEMENT

A. Bychkov

International Atomic Energy Agency

Madame President, colleagues and friends,

Let me begin by thanking you, Marta, for your stewardship of our conference and for the excellent summary you have just provided. This will help us to plan what we need to do next, both here in the Agency and in the Member States.

At the opening session, I said that I hoped we would learn new ideas from each other, which we could adopt to further improve our work in this important area. I know that there have been many interesting and useful presentations this week, both in the plenary sessions and in the interactive sessions. I believe many good experiences have been shared and good lessons learned.

Many people have commented that a lot of good work has been done in the area of human resource development since the 2010 human resource conference and that the presentations demonstrated good practical activities and experience. The change in focus from just the high level professionals to the broader workforce requirements, especially considering the needs of the vocational workforce, is to be welcomed. The increased focus on safety and the competence of regulators is also an appropriate development, especially considering public concerns after the Fukushima Daiichi accident.

As a Deputy Director General in the IAEA it is pleasing to have seen so many examples of IAEA guidance being implemented by Member States across all of the elements of capacity building. It is even more pleasing to see how the Member States have adapted this guidance to meet their own national needs, including activities in workforce planning, curriculum development and the application of the SARCoN and systemic approach to training approaches, to name just a few.

I also note that you would like to have a follow-up conference in four or five years' time, and we will try to ensure that this happens. On this point, we would welcome offers from Member States to host such a meeting in 2018 or 2019, especially those Member States with active programmes who can share their up-to-date experience and facilities.

I would also like to take this opportunity to thank our exhibitors, who added to the conference experience, to Hungary for jointly sponsoring our opening reception and to the French Mission for organizing the capacity building side event on Wednesday evening.

Finally, I would like to thank our own staff for organizing this event and ensuring it ran so smoothly.

Ladies and gentlemen, you have had a long week and have participated actively, and I am sure you are all looking forward to getting back to your respective homes, so I thank you once again for your participation and wish you all a safe journey home. Thank you.

CONFERENCE PRESIDENT

M. ZIAKOVA, Slovakia

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Capacity building is an essential first step in ensuring a sustainable supply of suitably qualified human resources, ready to assume responsibility for the safe, responsible and sustainable use of nuclear technologies. The IAEA's capacity building programmes cover all areas related to nuclear safety and seek to expand on existing capacity building infrastructures. The International Conference on Human Resource Development for Nuclear Power Programmes: Building and Sustaining Capacity emphasized the importance of human resources and capacity building programmes and reviewed developments in the area of human resources globally. The conference was attended by some 300 officials and experts from more than 60 Member States and 5 international organizations and provided a forum to share experiences and best practice across governments, industry, and educational and research institutions. The technical sessions focused on the global challenges of human resource development, educational and training, nuclear knowledge management, the establishment of knowledge networks and the preparation of the next generation of nuclear professionals.