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NUCLEAR POWER DEVELOPMENT IN THE 21st CENTURY AND THE KNOWLEDGE CHALLENGE

INTRODUCTION

At the beginning of 2011 the world continued to experience unprecedented changes to the global nuclear community. Established nuclear countries have been planning of expanding their reliance on nuclear power for the first time in many years, new entrant countries have been actively planning nuclear power development, and more countries are entering the reactor technology export business. The major drivers for these changes have been the population growth and economics, environmental concerns, and long-term security of both energy supply and cost. As a result of these drivers, the IAEA projections at the beginning of the year indicated that the installed nuclear capacity could practically double over the next two decades.

On March 11, an unbelievable catastrophic earthquake, followed by a tsunami with unaccounted strength and height, struck Japan and brought a core-melt accident to several of the reactors at Fukushima nuclear complex. A serious amount of radioactivity was release to the atmosphere and to the sea. 80 000 people have been evacuated. At the same time 30 000 people were killed by the earthquake and tsunami.

Though the human losses from the Fukushima nuclear accident itself have been practically eliminated and people have been protected, the economic consequences and the impact on the public attitude towards nuclear power is huge and will pertain in the future. At the same time the growth drivers for nuclear development are unlikely to change dramatically and it is highly probable that the installed capacity will continue to increase substantially over the remainder of this century although new challenges and new objectives may be set.

The immediate ones are those related to the safety of existing nuclear installations and they have already started by reassessing the safety performance in ex-

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treme events, recalculating margins, etc. The new designs will also be reassessed in stress conditions and probably new features might be added where necessary. The “soft” problems which are on the table such as safety culture, management behaviour, competence and knowledge mobilization and others will be more complex and difficult to address as they often relate to policies, cultural issues and leadership.

One of the main topics of immediate interest in the nuclear community will be the training and availability of qualified staff to meet the heavy demands of continuing and expanding programs. However, the ‘human resource development’ needs to include all the issues that affect human performance such as leadership, management systems, operating culture, knowledge management, and personal attitudes

CHALLENGES AND OPPORTUNITIES

We can assume that any human resource development challenges we have today will increase in the future for at least four reasons:

- New Projects.

The increasing number of new build projects will require the same on-going diligence and oversight in design, delivery, and supply as we have today. Vendors may be involved with several projects, which will require careful allocation of their experienced human resources. Constructors will have to continue to ensure that all activities, materials, and equipment fully meet safety requirements. Suppliers and manufacturers will have to ensure they can maintain the very high quality standards required for nuclear grade equipment. In other words, the entire supply and delivery chain will be expanding rapidly and will need to be managed carefully, including the appropriate oversight and regulatory activities.

- Operating Facilities.

There will be an increase not only in the number of operating nuclear facilities but also in all the associated activities to support them (such as mining, fuel cycles, transportation, and waste management). The operation of these facilities and the associated activities would be affected adversely by decision-making at any level or at any stage of the facility’s life-cycle that was deficient in knowledge or competence.

- New Entrants.

While most new plants will be built initially in established nuclear power countries, there will also be plants built in countries without nuclear power experience. These new entrants will require international human resource commitments over an indeterminate time to assist with the establishment of the robust nuclear infrastructure that established countries have developed over several decades.

- Training and Education.

The number of skilled people at all levels has to expand substantially, which means increased requirements for education and training. This involves more than courses from educational institutions. It is the nature of nuclear power that formal education is often just the beginning of the training process and that much hands-on practical experience is also necessary to gain the required competence.

NUCLEAR POWER IS DIFFERENT

While nuclear power shares some individual attributes with other large-scale and complex human undertakings, there are no other undertakings that have all its characteristics. The critical ones are discussed below:

- High Knowledge Level

Nuclear power requires a high level of knowledge in virtually every field of engineering and science. It would be difficult to make this statement for any other industry. It also requires highly trained and qualified constructors, operators, maintainers, and suppliers. Knowledge management and human resource development over a wide variety of disciplines and education levels are both critical to safety, security, and effective operations. It is well worth repeating that formal training is often just the beginning of a nuclear education.

- Long Timeframe

Establishing a nuclear power program is a very long-term commitment. It involves several decades of planning, building, and operation, followed by several more years of decommissioning and waste management. The requirement to sustain knowledge and the human resources that are the holders of that knowledge over such a long period requires cooperation between government, industry, and educational institutions to ensure that knowledge is passed effectively from generation to generation of nuclear experts.

- Regulation

Nuclear power is undoubtedly one of the most regulated industries, encompassing safety, security, health, environment, and safeguards. This requires knowledgeable and highly professional regulatory entities that can oversee a wide variety of activities throughout the entire life-cycle of a nuclear plant.

- Infrastructure

Nuclear power requires an extensive infrastructure. This includes nuclear laboratories, regulatory agencies, government departments with nuclear expertise, and educational institutions with the appropriate nuclear programs.

These characteristics mean that the sustained development of qualified human resources is critical for success. To understand the meaning of 'qualified human resources', we need to appreciate the difference between information and knowledge. Put simply, information is data while knowledge is the correct interpretation of the data. The generation and application of knowledge requires people who have the ability and training to understand the information. Perception and lack of technical rigor have no place in nuclear decisions.

The former statement is also true of how nuclear facilities are managed. Management training is an important human resource development activity. There is a view that anything can be managed by non-experts if the appropriate administrative structure and processes are in place. However, I do not believe this can be applied to the management of nuclear facilities. Managers with direct responsibilities for nuclear facilities must understand what they are managing to be able to provide the leadership, vision, and technical discipline required to ensure safe and ef-

fective operations. I feel that the same principles of management apply to nuclear regulation.

THE HUMAN RESOURCE CHALLENGE

To deal with the complexity and requirements for human resource development, a national nuclear program requires that the key stakeholders work together and that the roles and responsibilities of each stakeholder are clearly understood. This is a topic that could fill several volumes, so I have selected a few indicative examples from each stakeholder for illustration. Note that this discussion is focused on human resources and is not meant to cover all the nuclear responsibilities of the various stakeholders.

- Critical Role of Governments

Governments will always have a major role in nuclear energy for two main reasons. First, the life-cycle of a nuclear power program including waste management could be longer than that of most organizations. The concept of developing a nuclear program and then somehow handing the responsibilities to industry except for regulation is really not an option. Second, nuclear power incorporates international commitments by governments in such areas as safety, safeguards, and regulation. This means that governments have a requirement for the on-going development of human resources, whereas industry demands reflect the current business environment. Only governments have the permanence required to sustain the knowledge base and infrastructure over the required time frame.

Therefore, Government policy is critical to human resource development and knowledge management. An important starting point is a clear articulation of the national long-term vision that sets out the government's intentions. Without such a vision, attracting the best human resources can be difficult. Also, the long life-cycle of a nuclear power program requires a consistent long-term policy framework to ensure the appropriate people will be in place for safe, secure, and effective implementation.

Once the policies are clear, governments need to establish the infrastructure necessary to support nuclear technology and be prepared to maintain this infrastructure over the very long-term. The combination of supportive policies and appropriate infrastructure will ensure the continuing flow of talented human resources.

Perhaps the most essential infrastructure decision is the establishment of an independent and competent regulatory entity. This is an area where experience and judgment are at least as important as the formal training of human resources. The regulatory culture in developed nuclear countries has been established over many years and an essential human resource development requirement is to transfer this culture into new regulatory agencies.

The human resources associated with R&D are also an area for particular government attention since R&D develops the expertise and knowledge that underlie most nuclear-related activities such as safety, regulation, and waste management. Nuclear R&D also requires special facilities that are typically located in national laboratories, where high levels of radioactivity can be safely handled and charac-

terized. As an aside, while investments in such facilities are required for on-going support, the facilities can also be leveraged for future development: nuclear energy is still very young – younger than such technologies as television, computers, and all other major ways to produce electricity. Therefore, a considerable advancements in nuclear energy technology can be achieved only through on-going innovation.

- The Role of the IAEA

It is the nature of nuclear power that nuclear facilities are automatically part of the international community. Nuclear power requirements transcend national borders and mechanisms need to be in place to ensure strong international cooperation on everything from policy development to knowledge management. Therefore, IAEA programs are crucial for both established nuclear countries and new entrants. This is the only forum that allows all countries to meet on neutral ground to develop international consensus in virtually every area of peaceful use of nuclear technology.

The work carried out in the IAEA has resulted in much success over the past decade. We have seen the development of a large and impressive foundation for everything from the development of high level principles, such as international safety goals, all the way down to detailed best practices, such as laboratory procedures. This output is invaluable to member states that are developing and maintaining their human resources and infrastructure.

The IAEA has another key role to play in human resources development and knowledge management. New and established experts can interact on joint projects to advance knowledge. For human resource development, there are no other mechanisms that can accomplish this on an international scale. The flow of people, ideas, and knowledge are the hallmarks of a successful human resource development system, and IAEA can provide these opportunities. New entrant countries in particular could benefit greatly by exploring any and all of the IAEA options that are currently available to them.

A long-term international nuclear vision is also important for attracting talented people to the industry. The IAEA has been fostering cooperative international development of advanced nuclear technology through the coordination of such programs as INPRO and participation in Generation IV. Participation in these visionary activities demonstrates a commitment by governments to the longer-term that is not lost on young scientists and engineers who are considering a career in nuclear energy.

- The Role of Industry

Industry encompasses a wide variety of activities throughout the entire reactor life-cycle. A common attribute is that to remain competitive the various industries all hold specialized knowledge of their products and services and they all require highly trained people to develop and apply that knowledge.

Industry needs to be confident that both the supply and training of human resources are adequate. In the past, industry paid a lot of attention to recruiting and possibly less attention to the details of the education programs. However, now in many countries industry, government, and educational organizations are working together to enhance education programs and to attract qualified students

Two challenges in an operating nuclear facility are complacency and a lack of appreciation for 'what is not known' as opposed to 'what is known'. Therefore, training needs to go beyond the learning of basic skills. The best operators have learned to develop a questioning attitude towards their work and have also been instilled with the desire for continuous development and learning throughout their careers. In this respect, educational institutions and industry need to work together to ensure that the training programs go beyond the basic skills and reflect on how an operator actually should behave in a plant. In other words, perhaps the main focus is not how many people we can educate but rather the quality and completeness of what we are teaching them.

A critical challenge as shown recently in Fukushima accident is to find ways to access the specialized knowledge from industry and national laboratories when it is needed. As the number of plants increases, the demand for expertise will increase but the supply may be limited. In particular, this could be an issue in new entrant countries where there may be initially a lack of senior experts.

- The Role of Educational Institutions

While knowledge management and human resource development often focus on engineering and science, the nuclear industry also needs many other non-technical professions such as law, economics, and finance. Providing the opportunity for these experts to learn more about nuclear power at an early stage of their education would enhance their value to the industry.

In addition to university graduates, there are other areas of human resource development that are just as critical for a successful nuclear program. The operators and maintainers of nuclear facilities are the first line of defence with respect to safe and effective operation. We can address developing the mechanical skills, but it seems that the challenge is to go beyond this to look at how those skills will actually be applied and create the conditions to develop them.

CONCLUSIONS

For more than half a century nuclear power has gone through several critical stages of development and has emerged as a reliable and clean source of electricity generation which is vital for the current civilization. Three Miles Island's accident challenged the design development and training, while Chernobyl showed that safety culture is a fundamental attribute of any nuclear activity. Now nuclear power has faced unbelievable, catastrophic external events and while economic and other social losses have been incurred human life has been preserved.

A future challenge will be maintaining competence and managing knowledge and skills to guarantee safety and reliability at the highest level.

In developing peaceful uses of nuclear technology we have to watch that nuclear knowledge management is very robust and strong from the very beginning till the very end. All, involved in nuclear activities have to be forever diligent to sustain the knowledge systems, put into place. Nothing ever works on its own. It always has to be managed."