

# The Role of Nuclear Knowledge Management

## A. Introduction

The Agency has been a focal point for nuclear knowledge and information since its establishment in 1957. Nuclear knowledge management (NKM) came to the forefront formally in the 21st century, when several resolutions adopted at the Agency's General Conference, from 2002 onwards, included NKM as a high priority for Member States [1].

This document summarizes how NKM assists Member States in enhancing and supporting national nuclear policy and strategy and in ensuring safe and sustainable operation of nuclear facilities.

Nuclear knowledge is complex. Figure A-1 illustrates in three dimensions the aspects that need to be managed. The first dimension concerns the primary knowledge domains: people, processes and nuclear technology. People need to have the necessary combination of appropriate skills, experience, attitude and motivation. Processes methods and practices need to be controlled in an orderly and consistent way. Technology must be well understood and maintained. The second dimension concerns the nuclear life-cycle from research and development (R&D) through design and licensing, construction, commissioning, operations, maintenance, refurbishment and finally decommissioning. The third dimension recognises the different nature of individual expertise, organizational competency and national capacity.



FIG. A-1. NKM complexity and scope.

## B. Role of NKM in Nuclear Organizations

It has become increasingly clear to Member States that creating, sharing and transferring knowledge is critical for the safe and efficient management of any nuclear activity. Many Member States now have knowledge management programmes in place and are gaining a better understanding of the unique characteristics of nuclear knowledge to fulfil the missions and visions of each organization.

## **B.1. Research and Development (R&D)**

Innovation requires a holistic approach to problem solving and the ability to link separate concepts together to produce a new result. The process can be carried out by individuals, but better results are usually achieved by teamwork and group collaboration. Social interaction is therefore a key success factor for innovation. The resulting outcome is often an intangible knowledge asset that should be managed appropriately.

As R&D projects grow, international strategic alliances are increasingly required. Such collaboration and partnership between R&D institutes, government, universities and industry need a flexible approach and this process can be facilitated through various knowledge management tools and techniques.

Advanced nuclear education and the supply of qualified graduates are both important for nuclear R&D organizations to meet the ongoing demand for technical specialists. Successful delivery of nuclear education and training programmes now typically includes the transfer of knowledge through e-learning or online classroom environments as well as the traditional in-class lecture approach [2].

## **B.2. Nuclear Power Plants (NPPs)**

The importance of NKM activities within NPPs has been clear for the last decade. There are numerous examples of NKM good practices collected by the Agency from countries such as Canada, France, Germany, Japan, the Russian Federation, Ukraine, the United Kingdom and the United States of America, which are using NKM to solve new and existing challenges.

Long term operation requires the transfer of the most critical knowledge from one generation to another, and new-builds in embarking countries require new competencies and approaches to manage knowledge from the very beginning of the project. Today many NPPs have embedded NKM in their integrated management systems (IMS) to ensure that knowledge flows effectively through and within the organization.

Not only does NKM play an essential role in performance optimization, but also in supporting safety culture, learning, trust, collaboration and knowledge sharing.

## **B.3. Waste Management Facilities**

Most nuclear-related activities will produce associated radioactive waste. Waste management demands a commitment over several generations to protect living organisms and the environment. Information about the radioactive waste and its management or disposal should be collected and stored, regardless of the method of disposal that is eventually selected. Decisions on waste management approaches should be driven by technical knowledge based on experience accumulated over many years.

## **B.4. Regulators**

Regulatory bodies develop safety regulations and authorization processes, review and assess the safety and design documentation provided by the operating organization and inspect the facility, the vendors and manufacturers of safety related components. They must maintain the highest levels of competence to understand the design basis of nuclear technology systems.

## **C. Knowledge Management Survey of NPPs**

In 2013 the Agency published the results of an empirical survey that investigated the relationship between knowledge management practices in NPPs and their impact on organizational effectiveness [3]. A total of 124 ‘site organizations’ participated in the survey, representing a response rate of approximately 60 per cent. The findings show that NPP organizations with higher levels of support for knowledge management practices have higher levels of organizational effectiveness, measured against a range of performance measures that include safety, economic, operations, and maintenance indicators.

The findings clearly show that the mechanism by which knowledge management practices and information technology influence organizational effectiveness is not direct. It is primarily through their positive effect on organizational culture and on improving the quality of knowledge processes in the organization. These findings are helping NPP managers to better understand the mechanism by which knowledge management practices improve organizational effectiveness.

## **D. Role of NKM in Nuclear Education**

Education is a key component of knowledge management. Any national nuclear energy programme depends on the successful development of a competent workforce, through a sustainable academic or university education and industry training. Amongst a broad range of specialists, the nuclear engineer is a vital component of any nuclear workforce. The Agency is preparing a technical report on nuclear engineering education and curricula development focusing mainly on nuclear power [4].

Nuclear engineering education programmes can also be supported by the Agency’s services such as assistance visits, expert missions, provision of documentation and educational tools, coordination of educational networks, and train the trainers workshops for educational providers.

Education significantly benefits from educational networks, which allow for sharing of resources, experiences and best practices [5]. A number of national and regional networks and consortia are playing important roles in sharing curricula, programmes and opportunities for students. In Canada, for example, the University Network of Excellence in Nuclear Engineering has a strong link with the industry. In the Russian Federation, the National Research Nuclear University, centred on the Moscow Engineering Physics Institute, brings together 23 campuses across the country. In France, the International Institute of Nuclear Energy was created under the auspices of the French Council for Education and Training in Nuclear Energy. In the United Kingdom, the Nuclear Technology Education Consortium provides a one-stop shop for a range of postgraduate programmes. In Latin America, the Mexican Network for Education, Training and Nuclear Research and the Argentine Nuclear Education Network were created to facilitate cooperation and to promote the preservation of knowledge. In Asia, the Japan Nuclear Human Resource Development Network was created to coordinate and concentrate efforts. In Europe, the European Nuclear Education Network links universities from a number of countries and helps to promote quality uniform curricula in nuclear education. They have created a European Master of Science in Nuclear Engineering.

The Agency has also founded similar initiatives in Asia, Latin America and Africa: the Asian Network for Education in Nuclear Technology (ANENT), the Latin America Network for Education in Nuclear Technology (LANENT) and the AFRA Network for Education in Nuclear Science and Technology

(AFRA-NEST). There is a movement to form a new regional education network led by the Russian Federation and other Commonwealth of Independent States countries.

## **E. Application of NKM and Initiatives for Nuclear Education and Training in Member States**

Many Member States have applied nuclear knowledge management in their initiatives and activities and facilitated various programmes on nuclear education and training.

In the Russian Federation, building on positive results in developing an infrastructure for utilizing corporate knowledge to improve safety culture and organizational performance, the State Atomic Energy Corporation “Rosatom” established a Knowledge Management Programme to promote knowledge transfer and innovation. The programme consists of three parts: management of intellectual property rights; knowledge preservation through digitalization and content management; and management of scientific and technical communities with a special focus on the transfer of poorly formalized and non-formalized knowledge. Rosatom, in cooperation with the Agency, held the *International Conference on Knowledge Management and Innovation: Lessons Learned from Technology Leaders*, which attracted more than 400 specialists and 120 companies in December 2012.

In Europe, the Joint Research Centre of the European Commission launched the European Human Resources Observatory for the Nuclear Energy Sector (EHRO-N) to monitor the needs of human resources and expertise for the different stakeholders in nuclear energy and nuclear safety. EHRO-N is also preparing job taxonomy, applying the principles of the European Credit System for Vocational Education and Training to facilitate the validation, recognition and accumulation of work-related skills and knowledge acquired during a stay in another country or in different situations.

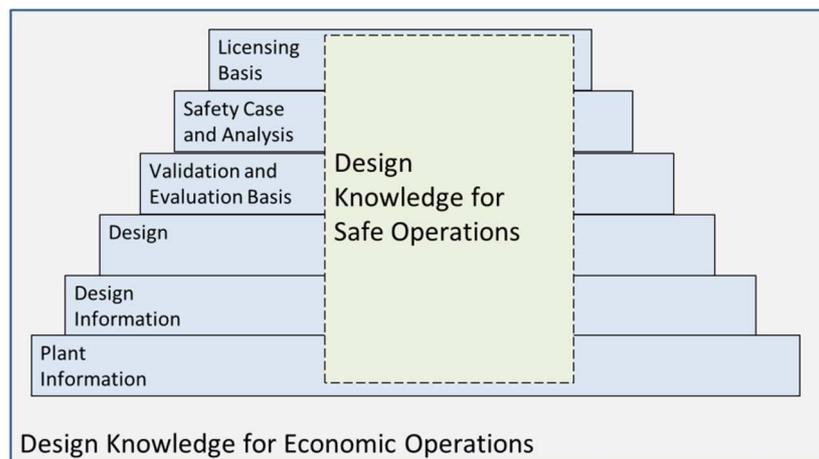
The World Nuclear University (WNU) is a global partnership committed to enhancing international education and leadership in the peaceful application of nuclear science and technology. WNU programmes, such as the Summer Institute, have focused on building nuclear leadership and providing orientation on the main issues that affect the current global nuclear industry. Over 3500 nuclear professionals and students from over 60 countries have participated in such programmes.

The Abdus Salam International Centre for Theoretical Physics, which operates under a tripartite agreement between the Italian government, the Agency, and the United Nations Educational, Scientific and Cultural Organization, has been a driving force behind global efforts to advance scientific expertise in developing countries. It organizes more than 60 international conferences, workshops, and numerous seminars and colloquiums including the Agency’s Nuclear Knowledge Management School and Nuclear Energy Management School for young nuclear professionals.

International conferences in this area are regularly conducted by different organizers all over the world such as the Conference on Nuclear Training and Education by the American Nuclear Society; the Nuclear Engineering Science and Technology conference by the European Nuclear Society; and the International Conference on Nuclear Human Resource Development for the Asia and Pacific region by the Japan Atomic Energy Agency as a part of the activities of the Japan Nuclear Human Resource Development Network.

## F. Role of Design Knowledge Management over the Life Cycle

Nuclear technology is complex. Plants are designed to achieve a high level of safety performance under normal conditions, during anticipated operational occurrences, and during design basis accidents. The Agency focuses its attention on the importance of the management and adequate understanding of design basis information from the beginning of the life cycle. For example, key knowledge about design assumptions or constraints, design or operating limits and conditions, in-service testing and inspection, maintenance history, operating performance and component life should be documented. They are important aspects of design knowledge that have to be preserved and managed. They are needed for safe operation, maintenance and any design changes. This knowledge is created, captured, used, modified, transferred, and maintained by various stakeholders and at various times over the life-cycles of the technology and the facility. Stakeholders producing and using this knowledge may include R&D organizations, vendors, regulators, owner-operators, technical service organizations, owners' groups and even suppliers. (Fig. F-1)



*FIG. F-1. Design basis information exists in many forms.*

It is important to establish effective knowledge transfer mechanisms from vendor to utility during the new-build process. The Agency is helping newcomer countries to understand the complexity of the challenge, in particular with respect to design knowledge and information. The documentation and the technical competencies needed to verify and validate the design basis are complex and very knowledge dependent. The volume of design information on the various systems and components is extremely large and must be subject to strict revision control, formal review and approval processes, as well as configuration management.

## **G. Communities of Practice**

Communities of practice (CoPs) are often at the heart of an organization's knowledge management system. They support the development and maintenance of organizational and personal competency through activities such as incorporating expertise into improved practices, recognizing and introducing new external knowledge, codifying and validating knowledge, as well as sharing knowledge by connecting experts, knowledge workers and knowledge seekers across organizational and national boundaries.

CoPs are networks of people who work on similar processes or in similar technical disciplines, and who come together to develop and share their knowledge for the benefit of themselves, other members of the community and their organizations. CoPs can be created and sustained formally or informally and organizations are now finding it beneficial to proactively enable CoPs. The lifespan of a community typically exceeds that of projects and organizational structures, making it an ideal mechanism for preserving nuclear expertise within a dynamic industry. CoPs interact with both face-to-face activities and information and communications technologies (ICT), making it possible for geographically dispersed networks to operate efficiently. An example of such a CoP is the Nuclear Energy Institute's Equipment Reliability Working Group.

The Agency actively cultivates CoPs and promotes their benefits by encouraging industry leaders to support them, publishing guidance on improving their performance, providing an ICT infrastructure for international cooperation, maintaining a directory of CoPs that enables connections between CoPs and individuals seeking to share expertise, encouraging existing CoPs to work with possible problems and promoting the creation of an international community of practice on NKM.

## **H. Importance of Knowledge Transfer to Developing Countries**

### **H.1. Capacity Assessment and Planning**

Many developing countries have pockets of achievement in nuclear technology applications. However, the lack of effective science, technology and innovation policy, which provide guidelines on technology transfer, including nuclear education, training and local technology development, continues to be a stumbling block for converting such achievement into sustainable national development.

Hence, there is a need to develop an integrated nuclear education system capability assessment and planning (CAP) framework, focused at the national level. This should take into consideration the full scope of government priority areas, external factors that affect the implementation, and the transfer and use of peaceful non-power applications of nuclear science and technology.

The Agency is developing a generic holistic model for the CAP framework through a set of pilot projects with countries in the African region that can be applied to other countries as appropriate.

### **H.2. Preservation of Reactor Technology Knowledge**

A taxonomy is a hierarchical system in which information or knowledge is categorized, allowing an understanding of how that body of knowledge can be broken down into parts, and how its various parts relate to one another. It enables users to find the targeted data easily and systematically.

Fast reactor technology continues to be developed in some Member States. The Agency has been developing the taxonomy for Fast Reactor Knowledge Organizational System (FR-KOS) and VVER Knowledge Organizational System (VVER-KOS). There is a potential risk of knowledge loss in these areas, as many specialists have already retired or are retiring and projects last several decades.

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. To this end the Agency is creating a database to preserve knowledge about major nuclear accidents.

## I. Conclusion

Nuclear knowledge and its effective management are critical drivers of both performance and safety for all nuclear organizations, from NPPs through to regulators and educational establishments. Nuclear facilities operate over very long timescales, during which operational conditions and technologies change. Knowledgeable decision-making is vital throughout this nuclear life-cycle as anything less than a full understanding of the potential consequences of decisions and actions may compromise nuclear safety. Effective knowledge management informs and supports business and decision processes throughout the whole nuclear sector by ensuring that the right knowledge is available when needed for decision makers and operators.

Organizations involved in the nuclear sector have demonstrated that they appreciate the significance and benefits of having in place robust and comprehensive knowledge management policy and procedures. During 2013, Member States actively contributed towards enhancing best practices in knowledge management. The Agency has continued to assist Member States in their endeavours by developing guidance on and methodologies for planning, designing and implementing nuclear knowledge management programmes. This assistance includes the fostering and preservation of nuclear education capabilities.

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