Managing Nuclear Knowledge

Proceedings of a Workshop
Trieste, 22–26 August 2005

IAEA ICTP WORLD NUCLEAR UNIVERSITY

IAEA
International Atomic Energy Agency

MANAGING NUCLEAR KNOWLEDGE

Printed by the IAEA in Austria
November 2006
STI/PUB/1266

PROCEEDINGS SERIES

MANAGING NUCLEAR KNOWLEDGE

PROCEEDINGS OF A WORKSHOP ON
MANAGING NUCLEAR KNOWLEDGE
ORGANIZED BY THE
INTERNATIONAL ATOMIC ENERGY AGENCY
IN COOPERATION WITH THE
ABDUS SALAM INTERNATIONAL CENTRE
FOR THEORETICAL PHYSICS
AND THE WORLD NUCLEAR UNIVERSITY
AND HELD IN TRIESTE, 22–26 AUGUST 2005

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2006

Sales and Promotion, Publishing Section
International Atomic Energy Agency
Wagramer Strasse 5
P.O. Box 100
1400 Vienna, Austria
fax: +43 1 2600 29302
tel.: +43 1 2600 22417
email: sales.publications@iaea.org
http://www.iaea.org/books

IAEA Library Cataloguing in Publication Data

Workshop on Managing Nuclear Knowledge (2005 : Trieste, Italy)
Managing nuclear knowledge : proceedings of a Workshop on Managing Nuclear Knowledge / organized by the International Atomic Energy Agency in cooperation with the Abdus Salam International Centre for Theoretical Physics and World Nuclear University and held in Trieste, 22–26 August 2005. — Vienna, 2006.
p. ; 24 cm. (Proceedings series, ISSN 0074-1884)
STI/PUB/1266
ISBN 92–0–109406–X
Includes bibliographical references.

1. Nuclear engineering — Congresses. 2. Nuclear energy — Congresses. 3. Knowledge management — Congresses. 4. Information technology — Congresses. 5. Nuclear engineering — Study and teaching – Congresses. I. International Atomic Energy Agency. II. Abdus Salam International Centre for Theoretical Physics. III. World Nuclear University. IV. Series: Proceedings series (International Atomic Energy Agency).

IAEAL 06–00464

FOREWORD

The nuclear sector, comprising the industry, governments and academia, is a knowledge based endeavour similar to other highly technological industries and relies heavily on the accumulation of knowledge. Recent trends, such as an ageing workforce, declining student enrolment and the risk of losing accumulated nuclear knowledge and experience, have drawn attention to the need for better management of nuclear knowledge. The workshop on Managing Nuclear Knowledge was jointly organized by the International Atomic Energy Agency (IAEA), the Abdus Salam International Centre for Theoretical Physics (ICTP) and the World Nuclear University (WNU), in Trieste, Italy from 22 to 26 August 2005, to increase the awareness of Member States regarding the challenge of nuclear knowledge management, to share the best practices and to provide a forum for the exchange of information among participating nuclear professionals.

The workshop was attended by 41 participants from 24 countries and three international organizations. Presentations by the participants covered a broad range of nuclear knowledge management issues, including the role of technology, preserving expert knowledge and preparing the new generation of nuclear workers. The IAEA, ICTP and WNU shared the significant role of assisting the Member States to develop effective nuclear knowledge management programmes and providing expert services in the subject areas.

These Proceedings summarize the main points emerging from the presentations, panel discussions and practical exercises conducted during the workshop. Most of the presented papers are included. The contributed papers and presentations are available on a CD-ROM attached to the back of this volume.

Appreciation is due to all the participants who contributed to this publication, particularly to M.R. Koorapaty for his assistance in its compilation and technical editing.

EDITORIAL NOTE

CONTENTS

HUMAN RESOURCES AND KNOWLEDGE TRANSFER IN THE NUCLEAR SECTOR (Session 3)

MANAGING AND PRESERVING KNOWLEDGE IN THE NUCLEAR SECTOR (Session 4)

SUMMARY

“The new paradigm is that the basic economic resource is no longer capital, nor natural resources, nor labour. It is and will be knowledge.”

Peter Drucker

1. INTRODUCTION

In recent years, knowledge is increasingly being recognized as a primary source of wealth. The nuclear industry has been losing its attractiveness to young professionals over the last few decades causing an adverse impact on preserving and further developing the accumulated nuclear knowledge and expertise over the last six decades. The loss of institutional memory of nuclear knowledge in governments, organizations and research institutes could become the precursor of problems in nuclear safety, security and non-proliferation. It could also negatively affect future potential to apply nuclear techniques and methods in important areas, such as medicine, agriculture, hydrology and food preservation, especially in developing countries.

It is in this context that the International Atomic Energy Agency (IAEA) organized the workshop on Managing Nuclear Knowledge, jointly with the Abdus Salam International Centre for Theoretical Physics (ICTP) and the World Nuclear University (WNU), in Trieste, Italy, from 22 to 26 August 2005. A total of 41 papers were presented by experts from 24 countries and three international organizations. The workshop comprised the following five sessions with a panel discussion at the end of each session:

Session 1: Policies and strategies in nuclear science and technology;
Session 2: Managing nuclear information resources;
Session 3: Human resources and knowledge transfer in the nuclear sector;
Session 4: Managing and preserving knowledge in the nuclear sector;
Session 5: Networking for education, training and knowledge transfer.

The main points emerging from the presentations and discussions are summarized session by session in the following section.

2. POLICIES AND STRATEGIES IN NUCLEAR SCIENCE AND TECHNOLOGY

The Canadian nuclear industry and its regulatory agency, the Canadian Nuclear Safety Commission (CNSC) recognized that nuclear knowledge management requires collaboration of all sectors of the industry and educational institutions. A number of initiatives have been implemented in order to maintain competency, capture and preserve existing knowledge, advance nuclear technology, develop future nuclear workers and maintain a critical level of R&D capabilities. The three basic elements of the Canadian strategy consist of: human resource management and training to maintain nuclear competency in the face of accelerated retirements of the current generation of experts; the development of advanced products and effective engineering tools to preserve the current technology and design basis; and effective information management systems to facilitate pooling and sharing of information among different entities. The web site CANTEACH (http://canteach.candu.org/) has been established as a comprehensive educational and reference library on CANDU technology. In order to ensure the supply of qualified nuclear engineers and scientists, the University Network of Excellence in Nuclear Engineering (UNENE) has been set up, bringing together six Canadian universities, Atomic Energy of Canada Limited (AECL), Canadian nuclear utilities and the CNSC.

Recognizing that knowledge management systems are of strategic importance in maintaining high performance levels over the plant lifetime, Canadian nuclear utilities are working towards formalizing and improving their knowledge management systems. An effective knowledge management performance assessment tool is needed to assist nuclear power plant organizations in understanding and benchmarking their current knowledge management practices both against industry peers (i.e. best practices) and against their past performance. Examples of knowledge management performance indicators include savings due to the reuse of knowledge; availability of networks; time to create new knowledge; accessibility and availability of knowledge management tools; information sharing; proportion of new employees suggesting new ideas; contribution to knowledge bases; and competence maintenance. Since the existing general knowledge management performance assessment frameworks are not tailored to the needs of nuclear power plants, AECL is supporting additional research and practical application experience in adapting these methods to meet the needs of nuclear power plants. The current focus of such research is on developing an initial nuclear power plant knowledge management benchmark survey.

A methodology, developed in Japan as a tool for measuring the economic effectiveness of nuclear knowledge management over the past five decades, utilized the concept of the size of the market, in terms of annual revenues, created in nuclear electricity generation and application of radiation technologies in the fields of industry, agriculture and medicine, in comparison with investments made in nuclear research and development.

The knowledge management strategy adopted by the Philippine Nuclear Research Institute (PNRI), with assistance from the IAEA, involves making knowledge management an integral part of the Integrated Management System (IMS), and the establishment of the PNRI intranet as a medium for discussions and sharing of knowledge. With a limited budget, the PNRI was able to develop its intranet using open sources (Linux based). Another component of the knowledge management strategy of the PNRI is its participation in regional networks which aim to preserve and share nuclear knowledge, such as the ANSN and ANENT and its participation in national government initiatives, such as the Philippine eLib (e-Library) project and the ScINET-PHIL (Science and Technology Information Network of the Philippines).

An amalgamation of the companies that designed and built all the United Kingdom commercial nuclear power stations led to the creation of the AMEC NNC, a premier technical nuclear engineering service provider to domestic and international clients. The most important assets of the organization are the know-how, experience and knowledge of its staff with more than 50 years experience in the nuclear industry both within the United Kingdom and abroad; an intimate understanding of regulatory requirements; a pragmatic and innovative approach to safety and engineering; flexible commercial approaches; and a track record of providing solutions to clients in the nuclear, defence and non-nuclear industries. Thus, the past experience and knowledge generated over five decades has been harnessed to create a profitable business.

As a field, knowledge management is relatively new. It is an amalgam of concepts borrowed from the artificial intelligence/knowledge based systems, software engineering, business process re-engineering, human resource management and organizational behaviour fields. Knowledge management has been most visibly introduced to the nuclear industry as a response to the ageing nuclear industry workforce in Member States, where the generation that designed, commissioned and initially operated these plants has begun to reach retirement age. Knowledge management tools for capture and transfer of knowledge from this ageing workforce to its younger replacements have been emphasized. While knowledge management has certainly been used successfully for this purpose, knowledge management has a larger, ongoing application over the life of a nuclear power plant and beyond.

Knowledge management is defined within the IAEA as an integrated, systematic approach to identifying, acquiring, transforming, developing, disseminating, using, sharing and preserving knowledge, relevant to achieving specified objectives. Knowledge management consists of three fundamental components: people, processes and technology. Knowledge management focuses on people and organizational culture to stimulate and nurture the

sharing and use of knowledge; on processes or methods to find, create, capture and share knowledge; and on technology to store and make knowledge accessible and to allow people to work together without being together. People are the most important component, because managing knowledge depends upon people's willingness to share and reuse knowledge.

The IAEA is developing a series of guidance documents on knowledge management, including knowledge preservation, knowledge loss risk assessment, and knowledge transfer in the nuclear sector. Related activities are being designed to assist nuclear organizations in Member States in applying this guidance and in benchmarking their practices against those of other industry organizations.

Retaining the benefits of nuclear safety experience — sometimes referred to as 'maintaining the safety case' — at operational reactors is another aspect of knowledge management that has been successfully addressed by the IAEA. A joint assistance mission by the IAEA and the World Association of Nuclear Operators (WANO) to the Krško nuclear plant in Slovenia focused on helping the plant management to systematically capture undocumented information, such as the safety and technical insights of retiring workers.

With regard to developing the next generation of nuclear scientists and engineers, while some countries, such as China and India, are turning out science and engineering graduates at record rates, the same does not hold true for several other Member States. The creation of the WNU as a global network of relevant industrial, educational and research institutions has been a step in the right direction. The insights gained from standardizing the curricula of the European Nuclear Engineering Network are being shared with other such networks and educational institutions. The first WNU Summer Institute, strongly supported by the IAEA, was held in 2005 with good results.

Replacement of the term 'quality assurance' by 'management system' reflects the evolution in the approach of the industry from the initial concept of 'quality control' (controlling the quality of products) through 'quality assurance' (the system to ensure the quality of products) to 'quality management' (the system to manage quality). The 'management system' is a set of interrelated or interacting elements that establishes policies and objectives and enables their achievement in an efficient and effective way. Nuclear knowledge management is considered a part of the Integrated Management System. In the context of knowledge management, a 'learning organization' is an organization whose key personnel view its future success as being based on continuous learning and adaptive behaviour.

3. MANAGING NUCLEAR INFORMATION RESOURCES

The International Nuclear Information System (INIS), established in 1970, has been developing as a mechanism for the exchange of information between Member States and the preservation of their nuclear knowledge, and is becoming a major contributor to IAEA knowledge management activities. International cooperation and decentralization are the distinguished features of this system; they allow maximum coverage to be achieved, cultural and language barriers to be overcome and every INIS Member to have the right to access the nuclear relevant information of all other INIS Members. It provides a comprehensive information reference service for publications and other types of literature in the nuclear field and the corresponding full texts of non-conventional literature (NCL). The INIS biblio-graphic database, which covers the period of 1970 to the present, contains over 2.6 million indexed references with English abstracts. The INIS NCL full text collection consists of two parts: the INIS NCL archive on microfiche, containing over 500 000 documents and the collection in electronic form, which contains over 250 000 documents.

INIS has recently started to digitize the INIS NCL microfiche archive of full texts in order to preserve deteriorating originals and to facilitate direct access to NCL documents, and plans to complete the project within 4–5 years. The result of this project will be a full text searchable database containing over 700 000 documents. The INIS Thesaurus has been identified as a major tool for the organization of, and access to, this knowledge.

To support Member States and the staff of the IAEA Secretariat, a comprehensive nuclear information portal is being established. The main objectives are connecting people; connecting people with information; sharing the information available in the IAEA Secretariat; and assisting in transformation of information into knowledge.

The first practical step in this direction was the development of the Annotated Internet Directory of Nuclear Information Resources (http://www.iaea.org/inis/ws) — a growing database of annotated links to web sites on the Internet that are related to various fields of nuclear science and technology and the IAEA's work.

Two initiatives to foster a direct contact between experts are the Find-an-Expert facility and the IAEA Nuclear Knowledge Desk. The Find-an-Expert facility (http://www-fae.iaea.org) helps experts who work on similar subjects to identify colleagues via the bibliographic records in the INIS database and to establish direct contacts. The IAEA Nuclear Knowledge Desk (http://www.iaea.org/km/nkd) facilitates a direct contact between the requester and an expert in the IAEA or by providing access to an adequate source of information.

The effective and efficient handling of large amounts of generic and detailed materials data is one of the basic elements of data administration within ongoing European research projects and networks. The Joint Research Centre of the European Commission, Institute of Energy at Petten, Netherlands, has developed a materials database (Mat-DB), whose structure has constantly grown from its initial mainframe stage without graphical user guidance, through PC client–server applications to the new web enabled interface. It is now integrated within the secure On-line Data Information Network (ODIN) portal (http://odin.jrc.nl). Final reports of R&D projects and drawings of any format can be stored within the source part of the database. Files can also be stored as blobs (binary large objects) into the database to keep track of large amounts of raw data. The whole project documentation including minutes of meetings can be stored in a structured manner (e.g. public and confidential areas) in the document management database (DoMa) and linked to project specific data sets. One of the motivations for developing the web enabled database application was to provide fast access to confidential, restricted and public data sets on the Petten Server and help to administer and distribute the data and documentation between European R&D partners.

The internal Joint Research Centre project SAFELIFE is dedicated to issues related to plant life management (PLIM) of ageing nuclear power plants. Within the frame of the SAFELIFE initiative, a new project is in progress in the Joint Research Centre Institute of Energy in cooperation with the Nuclear Research Institute Řež, Czech Republic, to collect all available information about reactor pressure vessels of WWER type reactors. A significant portion of the information is available with experts in the specialized field who have retired or are close to retirement. The preservation and use of their knowledge and experience would become more difficult or even impossible in a few years from now. More than 20 such specialists from WWER operating countries would help with the collection of rare publications dealing with material properties of WWER reactor pressure vessels (RPVs) and the results of studies related to the irradiation damage and testing of RPV steels, which are crucial for determining RPV life. This database of the bibliographies, supported by full text of all included publications with abstracts in English and in electronic format, will be made available to all the contributing specialists. It is also intended to prepare a state of the art report on radiation damage in WWER RPV steels with active participation of all contributing specialists. The results of the project will also be useful to young specialists of the new generation working on these plants in different countries since they would have access not only to the current views and knowledge but also to WWER history and background.

Knowledge management activities at the Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS) in Germany started in 2001, when the imminent loss of knowledge due to the forthcoming retirement of several experts was recognized. The knowledge management goal was maintaining and transferring competence. Another goal added after the first cycle of experience was that knowledge management should become part of the work processes and thus be integrated in everyday work. An information and document management system using an enterprise portal that provides a central access point to all documents and information was established, which improved cooperation and communication across the entire organization.

4. HUMAN RESOURCES AND KNOWLEDGE TRANSFER IN THE NUCLEAR SECTOR

The draft glossary of terms for knowledge management compiled by the IAEA was used as the basis for a discussion by the participants on issues and terminology related to knowledge management. A practical exercise was also conducted on aspects of capturing tacit knowledge. The results of the discussion and the practical exercise are highlighted below:

(a) Tacit knowledge refers to the accumulated knowledge held by researchers, scientists, technologists, engineers, plant managers and operators who are working, or have worked, within the industry. Capturing tacit knowledge is one of the most important elements of the preservation of nuclear knowledge. There are methodologies in place that have been used for tacit to tacit knowledge transfer or for tacit to explicit transfer. The benefit of the latter approach is that a tangible outcome from the process would be available on a long term basis to subsequent generations who will eventually manage the decommissioning of nuclear facilities. However, elicitation of tacit knowledge is a difficult process and might result in incomplete explicit knowledge.

(b) There are knowledge management experts who are optimistic that technical solutions can eventually be found to overcome the difficulties in eliciting tacit knowledge and transforming it into explicit knowledge. Others are sceptical about the conversion of tacit knowledge to explicit knowledge as they believe that it is futile and that the endeavour should be abandoned altogether because it would never be possible to capture the rich common-sense knowledge that underlies all human reasoning.

Hence, these researchers tend to focus on shaping corporate culture to encourage the sharing of knowledge.

(c) A case study presented by the IAEA summarized a successful programme of work that had been carried out within the research and technology function of British Nuclear Fuels plc (BNFL) between 2001 and 2004. The work had technology as its focus. A decision was made at the outset that knowledge associated with certain key technologies was the top priority. The programme was later extended to embrace a range of technologies of importance to the company as it was realized that the process was starting to move naturally into other subject areas. The pursuit of a 'knowledge thread' led to the discovery of connections that enabled a 'knowledge map' to be developed. The knowledge thread itself indicated that any attempt to capture knowledge on one technology, in isolation from related technologies, might prove to be counterproductive.

(d) For the practical exercise, the workshop participants were divided into four syndicate groups to discuss knowledge capture, knowledge transfer, knowledge gaps and knowledge targets, respectively. The process was facilitated and the results were reported back to all participants:

(i) *Knowledge capture:* The need to capture tacit knowledge is important for the effective and efficient work of the organization and to ensure that the knowledge and experience of senior staff are not lost due to retirement. Tacit knowledge of every worker has to be captured, especially those with several years of experience and close to retirement. However, it is important to capture knowledge as it is produced rather than waiting to capture it prior to the retirement of experts. The kind of knowledge that should be captured could be prioritized on the basis of a risk assessment of its loss. It is also important to capture the attitude of workers with good performance and ensure its transfer to the rest of the workforce. Examples of methodology and tools include maintaining an expert pool of retired staff to be available on request; awarding part time contracts on specific tasks to retirees; associating new workers with expert staff in joint work programmes; video recording of work to capture processes and skills; preparing documents on specific topics; and using experienced people to develop training material for abnormal operations. Developing guidance on knowledge preservation and capture strategies, tools and techniques, was identified as an urgent need.

(ii) *Knowledge transfer:* A strategy should first be developed on the preservation and use of transferred knowledge. The elements of such a strategy could be to validate the captured knowledge as correct and relevant; embed knowledge/information into processes wherever possible; and avoid past mistakes in building expert systems. Measures for transferring knowledge include post-job debriefs implemented on a peer to peer basis rather than a lecture by the boss, and storytelling, which is particularly suited to transferring operating experience. Dissemination of knowledge to universities and students, and working with them closely would encourage young people to consider working in the nuclear industry.

(iii) *Knowledge gaps:* Large age gaps in the staff of an organization could arise due to restructuring, introduction of new technology, modernization and eventually decommissioning. There are knowledge gaps, however, in the area of research reactors. It would be necessary to carry out an assessment of knowledge gaps. Most of the organizations in Eastern European countries are losing people due to salary issues and 'brain drain'. The next five to ten years would be a critical period with respect to the loss of experienced staff and in some cases losses of up to 50% are expected. It is therefore very important to develop appropriate strategies for human resource management, including graduate recruitment programmes. With regard to eliciting the tacit knowledge of retired staff, some difficulties being experienced include restrictions on the award of contracts to retirees and on employing them in some areas of work. Appropriate mechanisms need to be developed to facilitate utilization of retired staff.

(iv) *Knowledge targets:* The areas of nuclear knowledge targets identified include knowledge about all aspects of nuclear reactors; decommissioning of nuclear reactors and nuclear facilities; and development of nuclear technologies. Developing an appropriate organizational culture is considered the most important goal of an organization. The organizational culture should facilitate overcoming current problems, such as a lack of suitable succession planning for technology development and operations; a wide variation among different levels of management on the most important concerns to be addressed; and the unavailability of more than one expert in some important areas. Adoption of an appropriate strategy from the inception of nuclear power plant projects is expected to remove the subsequent need for specific knowledge capture/transfer projects.

A case study pertaining to the BNFL/British Nuclear Group Sellafield, United Kingdom, was presented. Several knowledge management tools and techniques, such as oral histories and exit interviews, rely on post hoc capture or acquisition of knowledge. The case study related to the development and use of radiological plant safety cases presented an alternative approach whereby knowledge is captured in situ. A database was constructed to improve the traditional method known as 'desktop studies' to draw up the engineering schedule, which sets out the list of safety equipment and their safety functions. The engineering schedule is compiled collaboratively, involving plant operators, safety assessors and engineers in lengthy brainstorming sessions lasting weeks or months. It has a number of subsequent roles, such as the creation of operating rules for a plant and the maintenance schedules, and helps determine where further safety and engineering assessment is required. The database was used to both drive the desktop meetings and to capture and report the data, and resulted in a number of key advantages. The desktop study was made more efficient and the gathering and managing of information more accurate. After gathering a number of engineering schedules using the same database, it could be used to answer queries regarding: common fault scenarios for a similar plant/process; the role of a similar safety system; the safety assumptions underpinning a piece of equipment; and elements of the safety case that will be impacted by a change to a piece of equipment. In this mode, the database has the potential to become a valuable knowledge management tool. Further, the database project was based upon a detailed understanding of the business process (i.e. safety case development) in which the knowledge is being created and used. As the design of the database supported both the immediate task at hand and also the wider knowledge management aspects, it was possible to overcome some of the 'resistance' that may have been encountered if the knowledge management application was perceived as an extra burden, over and above the normal duties.

The human resources situation at the Chilean Commission for Nuclear Energy (CCNE) was recognized to be posing a high risk to the future viability of the institution due to retirements and to a policy of non-replacement of the retired workforce. A Human Resource Management (HRM) Plan under the CCNE Strategic Plan is being prepared with the following objectives: to establish the competence profile of the 'national expert' in the nuclear and radiological sector, and to quantify those factors that give form and/or affect that profile; to implement human resource management practices in an integrated manner with the processes of planning, programming, budget allocation and evaluation; to implement instruments or policies regarding hiring, maintenance and retirement of the necessary personnel to maintain CCNE capabilities; to implement a nuclear knowledge management system in order to facilitate the identification, harvesting, preservation and transfer of the knowledge produced at the CCNE; and to implement a system of incentives to achieve the goals, objectives and mission of the CCNE.

In Germany, the experience gained to date in capturing the knowledge of experts who are leaving the project or organization showed that the identification of critical knowledge was still missing. The capturing process was informal and needed firm guidelines. However, strategies are in place which try to enlarge the scope of knowledge elicitation to that of knowledge representation and modelling. The concepts of knowledge representation have reached a stage where the tools are in place and the notion of knowledge representation and modelling, as well as the interest in it is spreading after the demonstration of pilot applications. In particular, it has been shown that these methods may appreciably improve navigation and retrieval of information. The process oriented knowledge management system has brought initial rewards. The project portal provides a place for every project, where all information and documentation relevant to the project is concentrated. This enables a quick and comprehensive view of the progress of the current project and the accomplishments of previous projects. In addition, methods related to process oriented knowledge management enhance the project information by state of the art reports and lessons learned. The utilization of these new tools is still in an early stage, but quickly gaining momentum.

Being a knowledge based organization, whose core activity is research and development in nuclear and related fields, the Malaysian Institute for Nuclear Technology Research (MINT) has formally introduced knowledge management in 2002. In the early stages, emphasis is being given to the cultural and human aspects of knowledge management with the objectives of intensifying innovation, achieving high customer and stakeholder satisfaction, developing innovative knowledge professionals and instituting a strong knowledge management culture. Priority is given to establishing those systems that support the maintenance and sharing of information and knowledge. Some knowledge management systems have been developed and others are in the process of development.

In 2002, the nuclear wing of the Tennessee Valley Authority (TVA-Nuclear) (in the United States of America) developed and implemented a process to retain critical knowledge and skills that could be lost due to the imminent retirement of a significant number of employees with critical knowledge and skills gained over a career of building and operating TVA's nuclear facilities. The process consists of the following steps: assess and prioritize the risks of losing critical knowledge and skills; develop and implement plans to capture critical knowledge or adapt to its loss; and monitor and evaluate action plans and priorities. The three step process is an element of the strategic approach to human resource management, which includes workforce planning, recruiting, training, leadership development and knowledge retention. The lessons learned from implementing this process include the following: typically the amount of critical knowledge at risk is less than suspected; the risk is greatest in specialized technical positions, which utilize problem solving strategies; current procedures may be weak, relying on experienced personnel rather than on strong processes and detailed work plans; and a range of options exists to mitigate knowledge loss, including codification, use of alternate resources, 'engineer-it-out', and education and training.

5. MANAGING AND PRESERVING KNOWLEDGE IN THE NUCLEAR SECTOR

The IAEA is developing guidance documents on nuclear knowledge management, including knowledge preservation and knowledge transfer in the nuclear sector to assist nuclear organizations in Member States in benchmarking their practices against those of other industry organizations. Knowledge management performance review criteria, developed by the IAEA, have been successfully used during the missions on knowledge management at Krško nuclear power plant, Slovenia, and Kozloduy nuclear power plant, Bulgaria.

An Integrated Safety Approach has been developed by the IAEA as a platform for linking its safety related statutory functions and its many associated activities. Knowledge management techniques are being used to develop process flows, map safety knowledge and to promote knowledge sharing. The first practical application was the establishment of a knowledge base related to safety aspects of ageing and long term operation of nuclear power plants. A large number of up to date training packages has been made available to the Member States in nuclear, radiation, transport and waste safety, using IAEA safety standards as a basis. The IAEA is also providing instruction to trainers in Member States on the use of these modules to ensure that the material is properly used and feedback received so that training services and material are improved and kept current. This approach adds a new dimension to transferring knowledge. Knowledge management and networking are being pursued as fundamental elements for achieving the vision of a global nuclear safety and security regime that provides for the protection of people and the environment from effects of ionizing radiation, the minimization of the likelihood of accidents that could endanger life and property, and effective mitigation of the effects of any such events.

In the framework of nuclear knowledge preservation, several subject oriented data and knowledge bases have been developed especially, the IAEA databases and web sites on the subjects of 'fast reactors' (http://www.iaea.org/

inis/aws/fnss), ‘accelerator driven systems’ (http://www-adsdb.iaea.org) and ‘gas cooled reactors’ (http://www.iaea.org/inis/aws/htgr).

Nuclear knowledge preservation has become a general issue of concern in the new countries that were former Soviet republics. Under the framework of the Commission of CIS States on the Peaceful Use of Atomic Energy, a special working group was created to conduct an estimate and analysis of the current status of nuclear knowledge preservation and management in countries that are now members of the Commonwealth of Independent States (CIS). At present, a draft technical document on methodology for knowledge preservation and management in the CIS has been developed. The document outlines the knowledge structure in the CIS and presents a common approach on nuclear knowledge preservation based on IAEA recommendations, taking into account national interests in the CIS. The document is expected to be finalized in early 2006.

The objective of a new Coordinated Research Project (CRP) on Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservation, commencing in 2005, is to support the preservation of nuclear knowledge in Member States and the IAEA by selection and implementation of appropriate cost effective technological solutions. The objective will be achieved through identification of alternative knowledge preservation methods and tools necessary to understand, capture, interpret, analyse, visualize, retrieve, archive and disseminate data and information, as well as the knowledge ultimately derived from them. The existing incompatibilities between data formats, software systems, methodologies, standards and models in Member States and the IAEA will require research and analysis in multiple disciplines.

Recognizing that nuclear knowledge management was necessary to fulfil its mandate, the CNSC has implemented a number of knowledge management initiatives. The CNSC regulates over 2500 licensees possessing over 4000 licences, including nuclear power reactors, research reactors, research facilities, uranium mines and mills, uranium fuel fabricators, hospitals, universities, cancer clinics, nuclear substance processing, industrial uses of nuclear substances, transportation, packaging and radioactive waste management facilities. The CNSC is one of the few nuclear regulators in the world that regulates all nuclear activities from ‘cradle to grave’. Based on experience with the implementation of knowledge management initiatives, some of the lessons learned for achieving success in knowledge management are listed below:

— Support of top and middle management is essential;
— Use of subject matter experts (SMEs) for developing training materials helps to capture their knowledge and experience;

— Use of SMEs for mentoring and 'job shadowing' promotes the transfer of knowledge;
— Roles, responsibilities and accountabilities must be clearly stated and understood;
— People or groups who are passionate about the knowledge management initiative should be used for the pilot projects;
— Implementation of new ideas and programmes takes time and requires patience.

Managing the CNSC's information, records and documents is another important part of knowledge management activities. Much of the recorded knowledge in the CNSC is in the form of emails, letters, staff analysis reports on licensing submissions and licensing decisions rendered by the Commission. It is crucial for staff to be able find and retrieve this information. One of the tools developed for this is the Records, Document and Information Management System which is a single repository for integrated records and document management. This will help CNSC staff retrieve and transfer its information and knowledge.

Germany faces a difficult situation as the Government decided to phase out nuclear energy as a source for electricity production. The 17 nuclear power plants currently in operation will be gradually disconnected from the grid within the next 15–20 years. During the whole phase out period, Germany has to maintain the capability to safely operate its nuclear power plants, to dismantle the shut down plants and to solve the problem of radioactive waste disposal in a scientifically and socially satisfactory way. The generation of experts that has participated in the construction or commissioning of nuclear power plants in Germany is currently reaching its retirement age. Due to the steady shrinkage of the German nuclear sector, not all retiring experts can be replaced. The reduced job prospects have resulted in a dramatic decline in the number of students enrolling in courses related to the nuclear sciences. Therefore, it is very difficult to find replacements who have the required education in nuclear technology. Under these circumstances it is a great challenge for the industry, utilities and regulatory authorities to transfer essential knowledge of the retiring experts to the remaining workforce.

Knowledge management is regarded by the Government of Germany as a key to preserve the necessary knowledge within the utilities and the regulatory body. A centralized coordination of knowledge management activities is particularly challenging in Germany because of the complicated regulatory structure. The regulatory body in Germany consists of a complicated network of Federal and state level authorities with their respective technical support organizations (TSOs). Every organization within this network is organizationally independent and thus has its own say on how to implement knowledge management programmes and strategies.

With respect to the diminishing research activities and the related problem of less and less students in the nuclear field, the Federal Government of Germany has appointed an Evaluation Committee, whose recommendations have led to the establishment of a Nuclear Technology Competency Pool (NTCP). The main objectives of the NTCP are to coordinate the publicly financed nuclear research activities of the main four nuclear research facilities in Germany and to provide research opportunities in the field of nuclear science and technology for qualified students.

Implementation of advanced information management techniques at the regulatory body (RS-portal) involves gathering all relevant information sources to perform the main tasks of the regulatory body into one web based portal. This portal, called the reactor safety (RS) portal, is currently under construction. It contains legal and technical information and databases, as well as information on generic safety issues (GESI).

In Lithuania, elements associated with knowledge management were implemented at Ignalina nuclear power plant Unit 1 and 2 during the early commissioning phases and nuclear knowledge is actively being captured and managed in many ways. The three main elements of the Nuclear Knowledge Management Strategy at Ignalina nuclear power plant are human resources management; capturing and preserving existing knowledge; sharing and pooling knowledge through the information management system.

The National Commission for Nuclear Activities Control (CNCAN) is the Romanian competent authority in the nuclear field, having responsibilities for regulation, licensing and control. CNCAN has taken some steps towards introducing knowledge management. A knowledge preservation policy is in place, based on several measures, including unlimited access to information provided through the Internet or intranet, access to dedicated publications, annual training programmes addressing the needs of the employees and the organization, knowledge dissemination sessions and increasing staff motivation.

The Nuclear Regulatory Authority of the Slovak Republic (UJD) is utilizing knowledge management to move towards better fulfilment of the organization’s duties and products and services. The UJD expends significant effort and resources for the management, preservation and evaluation of knowledge and information. It is regularly evaluated and improved to appropriately address external and internal environmental conditions. Sharing knowledge and information with partners (stakeholders) represents an important tool for preserving and maintaining the knowledge base of the UJD. Important information, including legislative documents and decisions, are published on the Internet and in case of controversy, each employee of the UJD has access to the Internet and technical information databases of the IAEA, OECD/NEA, and important partner organizations, such as the Nuclear Regulatory Commission (USA), STUK (Finland) and SUJB (Czech Republic). Employees of the UJD take part in training courses, technical visits, meetings, workshops and conferences of the IAEA and OECD/NEA. The system for sharing knowledge and information is periodically evaluated.

In compliance with an internal order of the UJD, each departing employee has to pass all relevant information, data and documents to his designated counterpart or his superior. The information thus passed on is evaluated. Exit interviews of leaving employees are common. The results are used in the improvement of the functioning of the UJD. Another method utilized for retaining knowledge and information is to create a redundancy in the jobs of employees to be retired.

Thailand is viewing nuclear energy as an alternative source for tomorrow's energy requirements. Knowledge management together with promotional policies from both the Government and private sector will determine the possibility of nuclear energy becoming an alternative source for Thailand. Nuclear knowledge management is being carried out at several institutes in Thailand, including Chlalongkorn University, Kasetsart University, Office of Atoms for Peace (OAP), Department of Alternative Energy Development and Efficiency (AEDE) and Electricity Generating Authority of Thailand (EGAT). At present, most of the support regarding nuclear knowledge management in Thailand is coming from the IAEA, European Union member States, Republic of Korea, India, China, the Russian Federation and Japan. Current measures to raise the awareness of the public on nuclear issues include cooperation between the universities and dissemination of information from sources such as INIS of the IAEA and the Asian Nuclear Safety Network (ANSN).

6. NETWORKING FOR EDUCATION, TRAINING AND KNOWLEDGE TRANSFER

Education and training are considered as important tools for preserving and sustaining knowledge. Recently networking of educational institutions has been adopted as a key strategy for capacity building and efficient use of available educational resources. The World Nuclear University (WNU) was launched in September 2003 by the World Nuclear Association (WNA). The founding supporters of the WNU are the IAEA, OECD/NEA, WANO and WNA and its membership covers 26 organizations worldwide. The mission of the WNU is to strengthen the international community of people and institutions so as to guide and further develop: the safe and increasing use of nuclear power as the one proven technology able to produce clean energy on a large global scale; and the many valuable applications of nuclear science and technology that contribute to sustainable agriculture, medicine, nutrition, industrial development, management of freshwater resources and environmental protection. The WNU aims to be instrumental in creating a network of leading institutions of nuclear learning.

The WNU is not a degree-awarding institution but a composite of its participating institutions, each of which will continue to teach and award degrees. Its mission is proposed to be accomplished through a worldwide network that coordinates, supports and draws on the strengths of established institutions of nuclear learning to promote academic rigour and high professional ethics in all phases of nuclear activity. A distinctive feature of the WNU is that there are no barriers to entry to its membership. It is a voluntary collaboration, which offers individuals and institutions the opportunity to bring their strengths, creativity and vision to the task of enhancing nuclear science and strengthening the nuclear profession for an ever wider global role.

Among WNU activities, the Summer Institute — as an academy for future leaders in nuclear science and technology — is currently at the most advanced stage. The concept of a WNU Summer Institute was developed through WNA–IAEA collaboration. The first Summer Institute was held in Idaho Falls, USA from 9 July to 20 August 2005. The WNU fellows from 33 countries were graduate students or employees affiliated with 63 different organizations. They participated in an intense six week educational experience featuring some of the foremost international leaders in science, engineering and the environment. The United States Department of Energy (DOE) provided leadership in launching this WNU innovation by generously agreeing to help sponsor the first annual WNU Summer Institute.

The Asian Network for Education in Nuclear Technology (ANENT), facilitated by the IAEA, was established in February 2004 to promote, manage and preserve nuclear knowledge; to ensure the continued availability of talented and qualified staff in the nuclear field in the Asian region; and to enhance the quality of human resources for the sustainability of nuclear technology. Universities, research centres, government agencies and other institutions involved in nuclear education and training in the region, are accepted as participating members of ANENT and international or regional networks as collaborating members. Currently there are 17 participating institutions from 11 countries (China, India, Indonesia, Malaysia, Mongolia, Pakistan, Philippines, Republic of Korea, Sri Lanka, Thailand and Vietnam) and three networks (Asian School of Nuclear Medicine, European Nuclear Engineering

Network and WNU) as collaborating members. The focus of ANENT in the short and medium term would be on enlarging the number of participating institutions and on the full operation of the ANENT web portal for the sharing of resources; and developing curricula, with pilots in nuclear engineering and nuclear medicine/radiation therapy.

The IAEA is also promoting and facilitating the establishment of regional nuclear and radiation safety networks to preserve existing knowledge and expertise, as well as to strengthen sharing and creation of new knowledge in these fields. Prominent examples are the Asian Nuclear Safety Network established in the frame of the IAEA's Programme on the Safety of Nuclear Installations in South East Asia, Pacific and Far East Countries, and the Ibero-American Radiation Safety Network in the frame of the Ibero-American Forum of Nuclear Regulators. Results to date are most encouraging and suggest that this pioneering work should be extended to other regions and eventually to a global nuclear safety network.

In order to capture nuclear knowledge in key areas that might be lost due to organizational evolution and the ageing of human resources, the Atomic Energy Commission of Argentina (CNEA) has promoted three projects with specific strategic objectives: the Research Reactors Knowledge Book known as LICREX; knowledge preservation of the Atucha type reactor; and the Nuclear Medicine Knowledge Latin American Net known as CLAMN. Using knowledge management techniques and benefiting from corporate resources of information and communications technologies, these projects are intended to protect, preserve and capture a part of the intellectual property generated by the Argentinian nuclear sector.

The University Network of Excellence in Nuclear Engineering (UNENE) is a non-profit corporation established by the Government of Canada. The Canadian Nuclear Safety Commission is also a member of the UNENE and contributes funding and expertise. This is a unique industry–university alliance established to ensure that the Canadian nuclear industry would continue to have a dependable supply of highly qualified and skilled professionals. Industry assists the universities in developing relevant research programmes, attracting bright students, and educating and training them to pursue the safe and efficient use of nuclear technology.

The temporary network, established through the European 5th Framework Programme project known as ENEN, was given a more permanent character by the foundation of the European Nuclear Education Network (ENEN) Association with the objective of preservation and further development of higher nuclear education and expertise. The activities of the ENEN Association are organized through five committees: teaching and academic affairs committee; advanced courses and research committee;

training and industrial projects committee; quality assurance committee; and knowledge management committee. During the 5th and 6th Framework Programme of the European Community, the ENEN Association made progress towards the delivery of the European Master's of Science in Nuclear Engineering (EMSNE) certificate course. Although the ENEN Association started with its focus on nuclear engineering education, the activities of its members within the scope of the 6th European Commission Framework project NEPTUNO will expand into the definition, harmonization and transnational recognition of professional training for key functions in nuclear industries and regulatory bodies.

The Eugene Wigner Course is an international training course organized on a yearly basis by four universities in different countries in the Central European region. It is a product of the ENEN Association and is financially supported by the IAEA. The lessons learned from this course would be helpful to other institutions that intend to organize similar courses on an international basis.

Seven years of experience have been gained by the University of Pavia in Italy and its branch, the University Institute for Advanced Study (IUSS) in conducting a pioneering Master's course in the field of non-power nuclear disciplines. The contribution of the IAEA and the symbiotic interaction of the School with industries and external research institutions have enabled the course to attain economic justification and sustainability and made the IUSS University of Pavia the national reference centre for professional education and applied activities in the field. Another factor that contributed to this result is the uniqueness of Pavia as a university town (the second oldest university in Italy with 17 university colleges) with an outstanding tradition in nuclear research.

POLICIES AND STRATEGIES IN NUCLEAR SCIENCE AND TECHNOLOGY

(Session 1)

Chairperson

Y. YANEV
IAEA

NUCLEAR KNOWLEDGE MANAGEMENT
Role of the IAEA

Y. YANEV
INIS and Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

The management of nuclear knowledge has emerged as a growing challenge in recent years, and the IAEA has had varied success in addressing different aspects of the problem. There has been good progress in the preservation of six decades of nuclear science and engineering studies through the IAEA International Nuclear Information System (INIS). Knowledge management related to retaining the benefits of nuclear safety experience — sometimes referred to as 'maintaining the safety case' — at operational reactors has also been successfully addressed. Regarding the aspect of developing the next generation of nuclear scientists and engineers, much remains to be done. While some countries (such as China and India) are turning out science and engineering graduates at record rates, the same does not hold true for others. The creation of the World Nuclear University, as a global network of relevant industrial, educational and research institutions, has been a step in the right direction. If the nuclear 'renaissance' is to become a reality, a lot more has to be done to ensure succession planning for the ageing nuclear workforce and retention of half a century of successful nuclear power operations.

1. INTRODUCTION

A threat to sustaining nuclear competence, recognized for quite some time, has been the declining interest in the wide scale use of nuclear energy, exacerbated by a marked decline in the number of appropriately qualified young nuclear professionals entering the field. This trend has an adverse impact on preserving and further developing the accumulated nuclear knowledge and expertise over the last six decades. While nuclear resurgence is not a foregone conclusion, the loss of institutional memory of nuclear knowledge in governments, organizations and research institutes could become the precursor of problems in nuclear safety and in non-proliferation. Loss of nuclear expertise could also negatively affect future potential to apply nuclear techniques and methods in important areas, such as medicine, agriculture, hydrology and food preservation, especially in developing countries. Therefore, the decline in the number of students of nuclear sciences and a growing number of universities giving up their nuclear education programmes have given rise to understandable concerns drawing the attention of governments, industry and academic institutions. The IAEA has responded to these concerns by establishing a dedicated programme on nuclear knowledge management and by initiating a number of activities which address different aspects of this problem.

In the last three years the primary focus of the IAEA's knowledge management activities has been on working with the Member States to better understand their needs in managing nuclear related knowledge and information, both in terms of succession planning and knowledge preservation. Important milestones in developing the IAEA approach to nuclear knowledge management have been the Meeting of Senior Officials on Managing Nuclear Knowledge in June 2002 in Vienna, called by the Director General; the Scientific Forum in 2003; and the Conference on Managing Nuclear Knowledge: Strategics and Human Resource Development, held in September 2004 in Saclay, France.

The results and achievements of the IAEA's nuclear knowledge management initiative have been receiving wide support and appreciation from the Member States, expressed in successive General Conference resolutions, statements in the Board of Governors and in international meetings. The strategic framework and actions for developing further nuclear knowledge management activities by the IAEA are described in the following discussion.

2. KNOWLEDGE MANAGEMENT CHALLENGES FACED BY THE IAEA

For half a century the IAEA has been the world centre for the sharing of scientific information and knowledge in the nuclear field with the objective "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". Knowledge management has recently emerged as a new 'paradigm', indicating a discontinuity in the process of creating, transferring and renovating nuclear knowledge. Three areas of priority have been identified by the IAEA together with the Member States:

— Developing appropriate responses to the needs of interested Member States in improving their national nuclear infrastructure, especially in the safe performance and life optimization of existing nuclear power plants, research reactors and other nuclear installations, and in supporting nuclear science and nuclear applications for sustainable development.

— Identifying and implementing measures to sustain and further enhance knowledge, competence and expertise, and maintaining a capability for the development of peaceful nuclear technology in the face of widening discontinuity, a lack of public confidence and rising security concerns.
— Acting as a catalyst for innovation and facilitating the resolution of future scientific and technological issues in all areas of nuclear science and technology.

A successful nuclear knowledge management programme will ensure that the IAEA remains an authoritative, independent and reliable source of nuclear information, knowledge and expertise to its Member States, thus maintaining the potential to meet their needs for capacity building, technology transfer and innovation.

Safety considerations would continue to be of the highest priority, as they have the most significant impact on the full utilization and further expansion of the peaceful uses of all nuclear technologies. In this context, IAEA assistance in managing the vast pool of nuclear safety related knowledge and creating new knowledge by combining, analysing, classifying and developing sustainable knowledge networks will be a critical challenge for the future.

A special area is the management of the ‘indigenous’ nuclear knowledge created within the IAEA. The most important aspects are the preservation, maintenance and enhancement of the information base, and the specific knowledge skills and technology for delivering credible assurances to the international community regarding the peaceful use of nuclear energy.

In order to meet these challenges, knowledge management has been instituted as an important component of the overall management strategy of the IAEA.

3. THE KNOWLEDGE MANAGEMENT MODEL OF THE IAEA

The IAEA knowledge management initiative has developed a dual objective: an external one oriented to the needs of Member States to manage nuclear knowledge and competence, and an internal one focused on knowledge management inside the organization. This dual nature of knowledge management is not specific to the IAEA and has also been recognized by other international organizations, such as the World Bank, the Food and Agriculture Organization of the United Nations and the World Health Organization. The externally focused knowledge management, which has dominated activities in the last two years, has been helpful to Member States by sensitizing governments and institutions to the importance of sustaining nuclear knowledge. Another outcome was the enhancement of their ability to preserve, create and exploit nuclear knowledge and transfer it to the next generation of nuclear professionals.

3.1. The IAEA internal knowledge management objective

Based on the definition of the United Nations Staff Council, the IAEA has developed a knowledge management objective for the medium term, which is the development of a systematic and integrated approach for identifying, managing and sharing the organization's knowledge, and creating new knowledge to enable maintaining a high level of competence in the areas of interest to Member States.

In order to remain responsive to the evolving needs of the Member States, the IAEA must explicitly and efficiently manage all informational and intellectual resources and capabilities of the organization. Knowledge of the IAEA includes but is not limited to nuclear databases, standards, technical and policy documents, project and travel reports, policies and procedures, as well as previously unarticulated expertise and experience.

Fulfilling the knowledge management objective will make the collective knowledge and experience of the organization available and accessible to individual staff members, who are expected to use it wisely and to help replenish the 'knowledge stock' by sharing their individual knowledge and experience. Such an ongoing cycle will encourage learning at work, will stimulate collaboration, and will empower members of staff to continually enhance their performance.

3.2. Developing the external knowledge management objective

The external knowledge management objective relates to how the IAEA involves nuclear knowledge management in programmatic activities with Member States. In this area, the IAEA has been guided by the relevant General Conference resolutions and by the recommendations of the IAEA's Senior Advisory Groups, such as the Standing Advisory Group on Nuclear Energy (SAGNE), the Standing Advisory Group for Nuclear Applications (SAGNA) and the International Nuclear Safety Advisory Group (INSAG) and by recommendations for international conferences, technical meetings and advisory panels. The four discernable elements of external knowledge management activities, which have been identified by the Member States, are:

(1) Enhancing nuclear education and training;
(2) Preserving and maintaining nuclear knowledge;

(3) Pooling and analysing nuclear knowledge;
(4) Promoting policy and guidance for nuclear knowledge management.

Over a very short period, the IAEA has underscored the importance of the nuclear knowledge management issue through various initiatives and activities undertaken during the last two programme cycles. With strong support from the Member States, the IAEA has elevated nuclear knowledge management to a central position and has launched or supported a number of important global initiatives in response. The objective of the IAEA in the medium term is to be *the independent, credible and authoritative international source of nuclear data, nuclear information and knowledge, and to maintain an adequate potential to meet the needs for capacity building, analysis and technology transfer in support of the peaceful, economically beneficial and safe use of atomic energy.*

Following the recent international conference and discussions in advisory committees, a strategic framework for developing nuclear knowledge management has emerged which involves six areas for the development of projects and activities, discussed in the following subsections.

3.2.1. New partnerships for the advancement of nuclear knowledge

Member States have suggested that the IAEA should continue to facilitate the development of new partnerships between government, industry and academia for the advancement of nuclear knowledge as indicated in the IAEA Medium Term Strategy. The setting up of Centres of Excellence in collaboration with distinguished institutions around the world for research, development and training in the peaceful uses of nuclear technology is a good example of such partnerships. The World Nuclear University Network promoted by the WNA and supported by the IAEA, the OECD Nuclear Energy Agency and the World Association of Nuclear Operators (WANO) is another example of fruitful collaboration among governments, industry and academia to nurture the next generation of leaders in the nuclear field.

3.2.2. Networks for education, training and knowledge transfer in nuclear science and technology

It has become increasingly clear that there is a need to consolidate the efforts of academia and industry in education and training. Partnerships of operating organizations with educational institutions and universities that provide qualified professionals for the nuclear industry should be assessed based upon medium and long term needs and strengthened where needed. In this regard, the IAEA is taking the necessary actions to initiate this kind of partnership and promote the creation of the next generation of personnel for the nuclear industry.

IAEA support for educational networks, such as the Asian Network for Education in Nuclear Technology (ANENT), is essential, as the IAEA plays a leading role in establishing and maintaining these instruments through coordinating the efforts of the Member States involved. Educational networking is considered now as a key strategy for capacity building and more efficient use of available resources. Establishing regional education networks for other world regions, such as Latin America or Africa, need to be considered.

As many nuclear organizations have taken positive and decisive steps to address the ageing workforce situation, including knowledge transfer to the next generation, the IAEA activities on human resources management and knowledge transfer have been highly supported. The IAEA and WANO have taken the issue of retrieving tacit safety knowledge available with senior plant operators and are working together to develop criteria for knowledge loss assessment.

3.2.3. Support in preserving, maintaining and widening the knowledge base

The IAEA Secretariat and Member States have taken steps towards nuclear knowledge preservation, dissemination and sharing through the effective participation of experts and individuals. Pilot knowledge preservation projects, such as the Fast Reactors Knowledge Preservation Initiative, have received wide support and other similar projects are in preparation in areas of concern. At the same time, the knowledge management objective of widening the knowledge base should be pursued both in the decommissioning of existing nuclear facilities and in developing innovative concepts and technologies through multidisciplinary projects, such as the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO), the Generation IV International Forum (GIF) and others.

3.2.4. Developing a coherent set of methodologies, guides and services for nuclear knowledge management

Several Member States are developing and implementing nuclear knowledge management initiatives to address a wide variety of issues associated with obtaining highly qualified staff for national nuclear programmes. Consequently, they recommended that the IAEA should focus its nuclear knowledge management activities on compiling good practices in the subject area; developing methodology, guidance and tools for strengthening training and education for capacity building; and facilitating the preservation of knowledge and information in Member States. WANO, OECD/NEA, WNA and others, as appropriate, should be involved in this process.

3.2.5. Introducing knowledge management as a tool to strengthen safety and security

The importance of knowledge management for safety (“knowledge management being at the heart of safety culture”) has been strongly emphasized by the Member States and the IAEA has been requested to further promote initiatives for sharing safety knowledge through networks, portals and through the development of appropriate documents. Prominent examples of initiatives already taken are the Asian Nuclear Safety Network (ANSN) established under an extra budgetary programme on the safety of nuclear installations in countries in South-east Asia, the Pacific and the Far East; and the Ibero-American Radiation Safety Network under the Ibero-American Forum of Nuclear Regulators.

3.2.6. ‘Knowledge packages’ and ‘knowledge organization systems’ in areas of interest to the IAEA Member States

‘Knowledge packages’ in all areas of importance and interest to IAEA Member States should be developed with the full use of IAEA information and knowledge resources. INIS and the IAEA Library, as major nuclear information holders, should work with individual departments (programmes) and assist in the development of relevant knowledge packages. ‘Knowledge organization systems’ may be generic and developed in areas such as nuclear power reactors and nuclear safety.

4. CONCLUSION

The management of nuclear knowledge has emerged as a growing challenge in recent years, and the IAEA has had varied success in addressing different aspects of the problem. Good progress has been made in terms of the preservation of six decades of nuclear science and engineering studies. A key indicator of success is that INIS has been expanding at a record pace, with over 100 000 bibliographic records and more than 250 000 electronic full text documents added regularly in the last few years. Students at 273 universities worldwide have free access to the INIS database and the system has grown to nearly one million authorized users.

A second aspect of knowledge management that has been successfully addressed relates to retaining the benefits of nuclear safety experience — sometimes referred to as ‘maintaining the safety case’ — at operational reactors. The IAEA recently participated in a joint assistance mission with WANO at the Krško nuclear plant in Slovenia, which focused on helping plant management to systematically capture undocumented information, such as the safety and technical insights of retiring workers. Building on a recommendation from that visit, policy guidance for nuclear power plants on this topic is expected to be developed with strategies and procedures based on best industry practices.

With regard to the third aspect of nuclear knowledge management related to developing the next generation of nuclear scientists and engineers, much more needs to be done. While some countries (such as China and India) are turning out science and engineering graduates at record rates, the same does not hold true for several other Member States. The creation of the World Nuclear University as a global network of relevant industrial, educational and research institutions has been a step in the right direction. The insights gained from standardizing the curricula of the European Nuclear Engineering Network are being shared with other such networks and educational institutions. The first World Nuclear University Summer Institute, strongly supported by the IAEA, was held in 2005 with good results. The workshop held in August 2005 in Trieste, at the Abdus Salam International Centre for Theoretical Physics, also focused on identifying the best practices in attracting and supporting young nuclear professionals.

In conclusion, if the nuclear ‘renaissance’ is to become a reality and meet the rising expectations of Member States, a lot more needs to be done to ensure the succession planning for the ageing nuclear workforce and the retention of half a century of successful nuclear power operations.

PERFORMANCE ASSESSMENT OF NUCLEAR KNOWLEDGE MANAGEMENT SYSTEMS

J. DE GROSBOIS
Information and Control Systems Division,
Atomic Energy of Canada Limited,
Mississauga, Ontario, Canada

Abstract

The paper introduces the topic of performance assessment of knowledge management systems in the context of nuclear power plant operations. It explains the importance and need for knowledge management performance assessment methods and tools appropriate for nuclear power plants and summarizes the existing industry approaches.

1. BACKGROUND

Effective knowledge management enhances a firm's capability to assimilate and exploit existing knowledge and is widely recognized in the management literature and practice as an important driver of long term performance and a necessary requirement for sustained commercial success. Its role is particularly important in technology intensive industries such as the nuclear industry. There is general agreement that knowledge management practices, if effectively applied to nuclear power plants, promise operational and safety performance improvement, reductions in operational and personnel safety risk, and opportunities for plant design improvements.

However, introducing and maintaining an effective knowledge management process in a nuclear plant is difficult and challenging. Utilities are making progress towards the implementation of different knowledge management processes and support systems but, in general, progress lags behind other industries and higher than expected implementation cost and effort are being experienced. Further, nuclear utilities are often not able to determine the effectiveness of knowledge management processes, and in some cases are not able to identify key areas in need of improvement. As a result, the current methods of implementing knowledge management systems have not provided all of the expected benefits.

Design, implementation and maintenance of knowledge management systems can be significantly improved and supported by proper methods and procedures for performance assessment of these systems. Adequate performance assessment can have a significant positive impact on the overall effectiveness of knowledge management practices. Meaningful performance measurement provides vital feedback needed for strategic management direction, control and decision making; communicates management goals or priorities; drives organizational behaviour; stimulates learning; provides a means of surveillance and motivation; and most of all plays a very important role in aligning knowledge management objectives with corporate strategy and value creation.

Although effective procedures for the performance assessment of knowledge management processes are greatly desired, particularly in the nuclear context, limited guidance is offered in the literature on how firms can (a) assess the adequacy and completeness of their existing knowledge management practices from an operational performance perspective; (b) identify the strategic objectives and direction needed for improvement; and (c) facilitate programme implementations to achieve it. The following summarizes assessment approaches for knowledge management system performance from the literature and considers their application in the context of nuclear power plant operations.

In order to develop an effective approach to assess knowledge management performance, an understanding of knowledge management theory and application is required. Improved knowledge flows and knowledge utilization have the potential to greatly impact the overall performance of the firm. In order to gain a better understanding of this, it is appropriate to first look to the existing literature and current best practices in knowledge management systems and assessment frameworks.

2. UNDERSTANDING KNOWLEDGE MANAGEMENT IN THE NUCLEAR POWER PLANT CONTEXT

There are numerous definitions of knowledge in the literature. There appears to be general agreement that knowledge is “information that is contextual, relevant and actionable” [1]. There are also different classifications of the types of knowledge found in the literature: a resource or a process [2]; at the individual, group or organization level; tacit versus explicit [3]; and factual, conceptual, procedural or metacognitive (i.e. knowledge about knowledge) [4]; various definitions of knowledge management also exist. However, most are consistent with the notion that it is a coordinated approach taken to managing the organization’s knowledge to improve oganizational performance, and it is acheived through knowledge creation, structuring and dissemination processes.

The objective of knowledge management is to promote the creation of new knowledge and innovation. It aims to reduce the cost of being effective and increase the pace of innovation. This includes initiatives, such as preserving existing knowledge, reducing the loss of intellectual capital from employees who leave, increasing collaboration and enhancing knowledge sharing, improving the skill level of employees, and increasing the productivity of workers by making knowledge accessible to all employees. Knowledge management enables a proactive quality culture in which increased knowledge helps staff do the right things, and do them right.

Numerous definitions of performance can be found in the literature, with some agreement that performance is "the level to which a goal is attained" [5]. Performance assessment (or measurement) is therefore "the acquisition and analysis of information about the actual attainment of company objectives and plans, and about factors that may influence this attainment" [6]. It is "the process of determining how successful organizations or individuals have been in attaining their objectives" [7]. The objectives of knowledge management performance assessment can thus be summarized as aiming to:

- Evaluate existing knowledge management practices;
- Identify the areas in need of improvement;
- Provide vital feedback needed for designing or improving a knowledge management system;
- Ensure that knowledge management supports informed decision making (at all levels);
- Support the alignment of knowledge management objectives with corporate strategy and value creation;
- Communicate management goals or priorities;
- Promote and motivate the desired behaviour of employees (motivate knowledge sharing, etc.);
- Stimulate learning and innovation.

The typical stages of knowledge management performance assessment are:

- Defining the objectives of knowledge management in the firm (this typically includes identifying knowledge flows and core competencies, and the different stakeholders and their goals and definitions of success);
- Identifying existing knowledge management practices (firms that are new to knowledge management are typically not well aware of many of the existing knowledge management processes in their organizations);

— Developing measures and measurement methods (the measures should be reliable, valid, actionable, etc., and there is a need to define what data will be collected and how it will be collected and how often);
— Measuring the progress periodically;
— Reviewing and refining the measures and measurement approaches.

Knowledge management processes are typically identified in general categories, such as knowledge generation, knowledge representation, knowledge storage, knowledge transfer (or sharing) and knowledge transformation. Specific knowledge dimensions to be measured are identified in each process area and serve as a basis for an assessment. Figure 1 illustrates the approach at a very high level of simplification.

3. EXISTING MEASUREMENT MODELS

Knowledge management principles and approaches evolved from the literature on intellectual capital theory. Several approaches to knowledge asset and intellectual capital measurement were precursors to the existing knowledge management measurement frameworks found in the literature and in practice, and remain quite useful and relevant as input for the development of a knowledge management assessment programme. Some well known examples of these include:

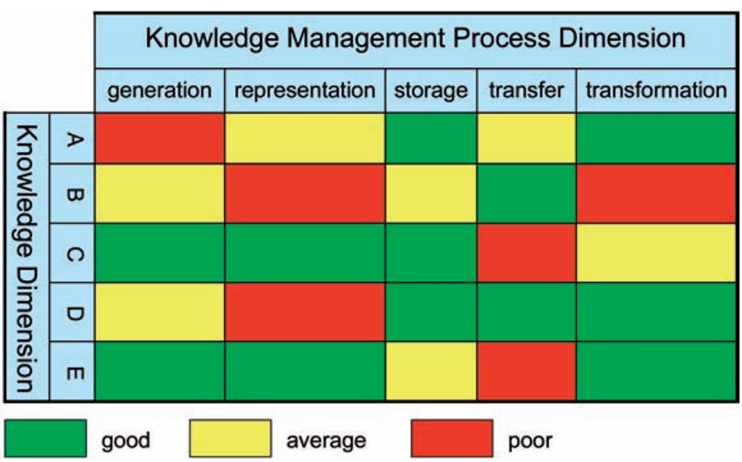

FIG. 1. Assessment of knowledge management performance by mapping.

— Skandia Navigator [8];
— Intangible Asset Monitor [9];
— Economic Value Added [10];
— Intellectual Asset Valuation;
— The Value Explorer [11];
— Calculated Intangible Value [9];
— Study by Intellectual Capital Management Group [12];
— Canadian Management Accountant's report on measuring knowledge assets [13].

From this basis, several well developed performance assessment frameworks have evolved specifically focused on knowledge management theory and practices. The "knowledge management performance scorecard" by de Gooijer [14] is a prime example. It is based on the "balanced scorecard" developed by Kaplan and Norton [15] for the assessment of a firm's performance, but adapted for the purpose of knowledge management performance assessment. This approach maps the objectives for knowledge management across the balanced scorecard's key result areas (financial performance, internal business processes, customers and growth). It incorporates a "knowledge management behaviour framework" that identifies seven levels of knowledge management skills, which represent an assessment of how individuals adopt the knowledge management tools.

Another useful example is the knowledge management assessment tool by Arthur Andersen (as described by de Jager, see Ref. [16]). It is a collaborative and qualitative benchmarking tool for knowledge management performance assessment. Collaborative benchmarking is based on a group of firms sharing knowledge about a particular activity and all of them are hoping to improve, based upon what they learn. Qualitative benchmarking is a comparison of processes or practices, instead of numerical outputs. There are five main components of the tool: leadership, culture, technology, measurement and process.

The International Most Admired Knowledge Enterprises (MAKE) Award conducted by Teleos and the KNOW Network is another widely used approach. It is an annual international award for best practices in knowledge driven organizations in Asia, Europe, North America, India and Japan. The approach rates companies against the following eight knowledge management performance dimensions:

— Creating a corporate knowledge driven culture;
— Developing 'knowledge workers' through senior management leadership;
— Delivering knowledge based products and solutions;

— Maximizing enterprise intellectual capital;
— Creating an environment for collaborative knowledge sharing;
— Creating a learning organization;
— Delivering value based on customer knowledge;
— Transforming enterprise knowledge into shareholder value.

There are many other existing knowledge management performance assessment methods, and some of the more established include:

— Knowledge Management PAS 2001: A Guide to Good Practice by British Standards Institute;
— Frid Framework™ for Enterprise Knowledge Management released by the Canadian Institute of Knowledge Management;
— KM Roadmap to Success by American Productivity & Quality Centre;
— Interim KM Standard AS 5037 issued by KM Standards Australia;
— European Guide to Good Practice in Knowledge Management by the European Standardization Committee.

4. WHY KNOWLEDGE MANAGEMENT IS IMPORTANT TO NUCLEAR POWER PLANTS

Some of the knowledge management challenges faced by the nuclear industry include a complex technology base (both design basis as well as operation and management infrastructure); an extremely long technology and plant life cycle; high capital intensiveness; the need for economic and risk based asset management strategies; extensive dependence on multidisciplinary technologies and expertise; competing operational objectives; and the ongoing need for simultaneous integrated coordination of many complex physical and human systems. Stringent requirements for safety, environmental qualification, nuclear quality assurance, and equipment and design configuration management, must be maintained and achieved. All this must be considered in the context of potentially high hazards that must be systematically managed in a regulated industry environment to demonstrably low tolerable risks.

The successful and efficient operation of any nuclear power plant is highly dependent on effective knowledge management processes. A fundamental premise is that the knowledge management system in the nuclear power plant context is vital to achieving overall utility performance. Knowledge management processes are believed to enhance and maintain a proactive organizational culture that focuses on problem avoidance. By enabling better utilization of industry, organizational, departmental and individual knowledge, nuclear power plants with active knowledge management programmes achieve better decision making and high work process efficiency by establishing a knowledge management enabled quality culture. Both tacit and explicit knowledge in the firm are actively managed as part of an 'integrated and shared knowledge base' that is supported by an information management infrastructure (i.e. information systems and technology, work processes, etc.). Figure 2 shows these associations.

5. SUMMARY AND CONCLUSIONS

There is a need to approach knowledge management in nuclear plants as a strategic corporate system. This is increasingly being recognized as an essential strategy in nuclear power plants. Most nuclear utilities are working towards formalizing and improving their knowledge management systems but, as in every industry, there are industry leaders and industry 'laggers'. An effective knowledge management performance assessment tool is needed to assist nuclear power plant organizations in understanding and benchmarking their current knowledge management practices both against industry peers (i.e. best practices) and against their past performance. Many general knowledge management performance assessment frameworks exist, but these are not tailored to the needs of nuclear power plants. Additional research and practical application experience is needed to understand how these methods can be best adapted for nuclear power plants. AECL is supporting the author's research in

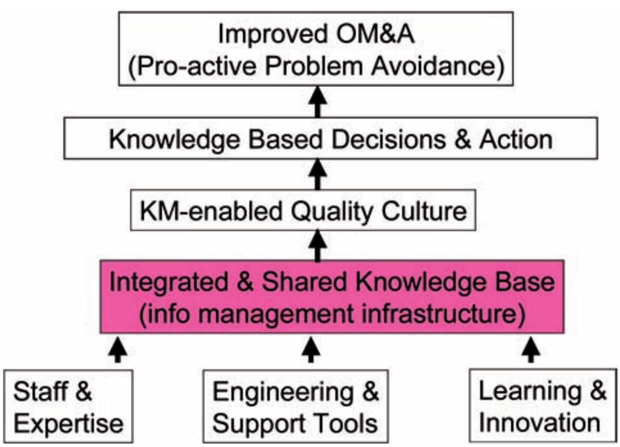

FIG. 2. Linking knowledge management to plant performance.

this area and the current focus is on developing an initial nuclear power plant knowledge management benchmark survey.

REFERENCES

[1] SOLIMAN, F., YOUSSEF, M., "The role of critical information in enterprise knowledge management", Ind. Manage. & Data Syst. **103** 7 (2003) 484–90.

[2] ASSUDANI, R.H., Catching the chameleon: Understanding the elusive term 'knowledge', J. Knowledge Manage. **9** 2 (2005) 31–44.

[3] NONAKA, I., TAKEUCHI, H. The Knowledge-Creating Company, Oxford University Press, New York (1995).

[4] ANDERSON, L.W., et al., Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives, Longman, New York (1998).

[5] DWIGHT, R.A., "Concepts for measuring maintenance performance", in New Developments in Maintenance: An International View (Martin, H.H., Ed.), Moret Ernst and Young, Utrecht (1995).

[6] KERSSENS VAN DRONGELEN, I.C., COOK, A., Design principles for the development of measurement systems for research and development processes, R&D Manage. **27** 4 (1997) 345–357.

[7] SINCLAIR, D., ZAIRI, M., Effective process management through performance measurement: Part 3 — an integrated model of total quality-based performance measurement, Bus. Process Re-eng. Manage. J. **1** 3 (1995) 50–65.

[8] EDVINSSON, L., MALONE, M.S., Intellectual Capital: Realizing Your Company's True Value by Finding its Hidden Brainpower, Harper Business, New York (1997).

[9] SVEIBY, K.E., The New Organizational Wealth: Managing & Measuring Knowledge-Based Assets, Berret-Koehler Publishers, San Francisco, CA (1997).

[10] STEWART, T.A., Intellectual Capital: The New Wealth of Organizations, Doubleday/Currency, New York (1997).

[11] ANDRIESSEN, D., TISSEN, R., Weightless Wealth: Find Your Real Value in a Future of Intangible Assets, Financial Times and Prentice-Hall, London (2000).

[12] AHMED, P.K., LIM, K.K., ZAIRI, M., Measurement practice for knowledge management, J. Workplace Learning **11** 8 (1999) 304–12.

[13] CANADIAN MANAGEMENT ACCOUNTANTS, Focus Group Draft: Measuring Knowledge Assets, CMA, Mississauga, Canada (1999).

[14] DE GOOIJER, J., Designing a knowledge management performance framework, J. Knowledge Manage. **4** 4 (2000), 303–310.

[15] KAPLAN, R., NORTON, D., The Balanced Scorecard, Harvard Business School, Boston, MA (1996).

[16] DE JAGER, M., The KMAT: Benchmarking knowledge management, Library Manage. **20** 7 (1999) 367–372.

REQUIREMENTS AND GENERIC GUIDANCE FOR A MANAGEMENT SYSTEM

A. KOSILOV
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

The term ‘management system’ has been adopted instead of ‘quality assurance’. ‘Management system’ reflects the evolution in the approach from the initial concept of ‘quality control’ (controlling the quality of products) through ‘quality assurance’ (the system to ensure the quality of products) and ‘quality management’ (the system to manage quality). The ‘management system’ is a set of interrelated or interacting elements (system) that establishes policies and objectives and which enables those objectives to be achieved in an efficient and effective way. Nuclear knowledge management is considered a part of an integrated management system, which integrates all the components of an organization into one coherent management system. The paper describes nuclear knowledge management in the context of the IAEA approach to establish the requirements for the integrated management system. The paper also presents nuclear knowledge management terminology and the concept of a ‘learning organization’ as a means for continuous improvement.

1. NUCLEAR KNOWLEDGE MANAGEMENT TERMINOLOGY

The Nuclear Knowledge Management Glossary has been developed by the IAEA team of C.R. Chapman (UK), L.B. Durham (USA), T.J. Mazour (IAEA) and A. Kosilov (IAEA) [1]. Knowledge management itself is defined as an integrated, systematic approach to identifying, managing and sharing an organization’s knowledge, and enabling persons to create new knowledge collectively and thereby help achieve the objectives of that organization. Knowledge management helps an organization to gain insight and understanding from its own experience. Specific activities in knowledge management help the organization to better acquire, store and utilize knowledge. The Glossary contains more then 120 terms representing different aspects of knowledge management in the nuclear field. Many terms contain comments providing additional information and/or clarifications.

2. REQUIREMENTS AND GENERIC GUIDANCE FOR A MANAGEMENT SYSTEM

The IAEA is developing for publication some Safety Requirements which establishe the requirements to implement a management system that integrates safety, health, environmental, security, quality and economic objectives. This publication will provide the means to address the safety objectives and principles regarding management systems presented in the IAEA Safety Fundamentals publication. It will replace the IAEA 50-C-Q Code on Quality Assurance for Safety in Nuclear Power Plants and other Nuclear Installations, contained in the Safety Series No. 50-C/SG-Q (1996). The IAEA Code 50-C-Q (1996) and developments within the International Organization for Standardization (ISO) ISO 9001:2000, as well as ISO14001:1996 publications were considered in developing this set of management system requirements. In addition, the experience of Member States in developing, implementing and improving Management Systems was taken into account.

The management system is a set of interrelated or interacting elements (system) that establishes policies and objectives, and which enables those objectives to be achieved in an efficient and effective way. Nuclear knowledge management is considered a part of an integrated management system, which integrates all the components of an organization into one coherent management system.

Knowledge is the key resource of most organizations in today's world. To manage it effectively requires the concept of organizational knowledge rather than simply knowledge that is centred on individuals. This needs to be addressed through the concept of an organizational core competency that has proven itself within many organizations in Member States. The management system shall promote and support nuclear knowledge management as a primary opportunity for achieving competitive advantage and maintaining a high level of safety. This approach shall ensure that organizations are able to demonstrate their long term competitiveness and sustainability through actively managing their information and knowledge as a strategic resource supporting the establishment and maintenance of the performance of the organization. The knowledge management process within an organization is to be addressed and improved. The knowledge management process shall include knowledge identification, knowledge acquisition and development, knowledge dissemination and use, and knowledge preservation.

Information and knowledge resources include technical information in the form of scientific research, engineering analysis, design documentation, operational data, maintenance records, regulatory reviews and other documents and data. It also includes knowledge embodied in people — scientists, engineers and technicians — which may belong to different institutions engaged in the activities of the organization. The information and knowledge resources shall be determined, provided and properly managed [2, 3].

3. BUILDING A LEARNING ORGANIZATION

In the context of a knowledge management learning organization is an organization whose key members of staff view its future success as being based on continuous learning and adaptive behaviour [4]. The organization, therefore, becomes renown for creating, acquiring, interpreting and retaining knowledge and then modifying its behaviour to reflect new knowledge and insights. In other words, organizational learning means the process of improving actions through better knowledge and understanding. Learning organizations are skilled in five main activities: systematic problem solving, experimentation with new approaches, learning from their own experience and past history, learning from the experiences and best practices of others, and transferring knowledge quickly and efficiently throughout the organization. By creating systems and processes that support these activities and integrating them into daily operations, companies can manage their learning more efficiently.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Knowledge Management for Nuclear Industry Operating Organizations, IAEA-TECDOC-1510, IAEA, Vienna (in preparation).
[2] http://www.iaea.org/km
[3] http://www-ns.iaea.org/standards/documentpages/management-systems.htm
[4] GARVIN, D.A., Building a Learning Organization, Harvard Business Review, Boston, MA (1998) pp. 47–79.

KNOWLEDGE MANAGEMENT INITIATIVES AT THE PHILIPPINE NUCLEAR RESEARCH INSTITUTE

C.C. BERNIDO, A.E.L. CONJARES, C.G. HALNIN, A.B. ANDEN
Philippine Nuclear Research Institute,
Diliman, Quezon City,
Philippines

Abstract

The Philippine Nuclear Research Institute (PNRI), with assistance from the IAEA, is in the process of setting up an integrated management system (IMS) for the whole Institute, following the guidelines published by the IAEA (Refs [1–3]). The strategy for setting up a knowledge management system at the PNRI involves making knowledge management an integral part of the IMS, and the establishment of the PNRI intranet as a medium for discussions and sharing of knowledge. With its limited budget, the PNRI intranet was developed using open sources (Linux based). Also part of the knowledge management activities of the PNRI is its participation in regional networks which aim to preserve and share nuclear knowledge, such as the Asian Nuclear Safety Network (ANSN) and the Asian Network for Education in Nuclear Technology (ANENT), and its participation in National Government initiatives such as the Philippine eLib project and the ScINET-PHIL.

1. BACKGROUND

The Philippine Nuclear Research Institute (PNRI), an Institute under the Department of Science and Technology (DOST), is the agency mandated to develop and regulate the different applications of nuclear science and technology in the Philippines. Its activities include nuclear research, nuclear regulations and nuclear services including training. The PNRI was formerly the Philippine Atomic Energy Commission prior to a government reorganization and was the regulatory body involved in the licensing of the first Philippine nuclear power plant built in the 1970s and which was mothballed in 1986 after being almost 90% completed. The PNRI's facilities include, in addition to research laboratories, a 3 MW Triga type research reactor, which is at present on extended shutdown and is planned to be decommissioned; a ^{60}Co pilot scale irradiation facility; a radwaste facility; and a Secondary Standards Dosimetry Laboratory.

Knowledge management has been defined in the glossary of IAEA-TECDOC-1510 [1] as “an integrated, systematic approach to identifying, managing and sharing an organization’s knowledge, and enabling persons to create new knowledge collectively and thereby help achieve the objectives of that organization.” The PNRI stands to benefit from knowledge management in order to preserve institutional knowledge and memory, especially the tacit and explicit knowledge gained from the regulatory activities of the first nuclear power plant, the operation of its research reactor, and its research in the nuclear field. It also suffers from the problem of ageing workers in the nuclear field, as with other organizations worldwide. Knowledge management at the PNRI has benefited from IAEA activities and initiatives, such as knowledge management workshops and knowledge management seminars in connection with the setting up of the Asian Nuclear Safety Network (ANSN) national centre in the Philippines. The knowledge management initiatives at the PNRI address the following aspects:

— Transforming tacit knowledge to explicit or organizational knowledge;
— Knowledge sharing or dissemination within the organization;
— Communities of practice within and outside the PNRI;
— Knowledge base or repository;
— Networking with other organizations.

2. KNOWLEDGE MANAGEMENT STRATEGY AS A PART OF AN INTEGRATED MANAGEMENT SYSTEM

With assistance from the IAEA, the PNRI is in the process of developing and setting up an integrated management system (IMS) for the whole Institute following the guidelines published by the IAEA (see Refs [2, 3]. The IMS integrates safety, health, environmental, security, quality, economic and other considerations [2]. Although ISO certification is not a requirement of the IMS but is optional, ISO 14001:1996 (Environmental Management Systems) and ISO 9001:200 (Quality Management Systems) were considered in developing the IMS requirements in Ref. [2]. According to Ref. [3], “the information and knowledge of the organization shall be managed as a resource.” The strategy for setting up a knowledge management system at the PNRI involves making knowledge management an integral part of the IMS. Documentation is an important part of the IMS. The records and documentation requirements of the IMS will systematize the writing down of ‘tacit knowledge’ and allow it to be shared with others. Furthermore, the implementation of the IMS will result in systematic records management and a systematic writing down of unwritten procedures and results. As stated in Ref. [2], the IMS documents include the following:

(1) Policy statements of the organization;
(2) Description of the management system;
(3) Organizational structure;
(4) Definition of the functional responsibilities, accountabilities and levels of authority and interfaces for those managing, performing and assessing work;
(5) Processes and supporting information that describe how work is to be managed, performed and assessed.

Assessment is an important part of the IMS; assessment requires the writing down of reports for project monitoring and evaluation. The systematic documentation of project outputs and research results, and putting them into a database for easy retrieval and sharing of information will be part of the PNRI IMS. The functions of the internal audit unit at the PNRI, which used to do only financial audit, are now expanded to include an audit of projects, researches and operations.

According to Denning [4], organizing for knowledge management is one of the seven basics of knowledge management, together with having a strategy, budget, incentives for knowledge management, communities of practice, technology of knowledge management and measurement of knowledge management strategy. A coordinating organizational unit for knowledge management is essential for its success, and this is not necessarily the IT group. At the PNRI, since knowledge management is part of the activities of the IMS, the IMS Project Committee oversees the implementation of knowledge management in coordination with the IT group.

3. KNOWLEDGE MANAGEMENT STRATEGY: KNOWLEDGE SHARING THROUGH THE PNRI INTRANET

Traditional practices for knowledge sharing at the PNRI include briefing and debriefing sessions of invited experts, lecture series among the researchers and echo seminars given by personnel who attend training courses and workshops conducted locally or outside the country. More recently, the PNRI intranet has been established as a medium for discussions and sharing of knowledge. With its very limited budget, the PNRI could not afford to buy software such as Livelink. The intranet was developed by the PNRI IT group using open sources (Linux based), and has features similar to Livelink. These features include news and articles, 'egroup' creation, discussion fora at different levels (communities of practice), a document repository, knowledge base resources, integrated on-line services, a link to the PNRI web mail, and a staff directory.

Access to the PNRI intranet requires a password, and it has the following different levels of access:

(1) Director, Deputy Director and four Division Chiefs;
(2) Senior staff;
(3) Each of the four Division Chiefs (i.e. Atomic Research; Nuclear Regulations, Licensing and Safeguards; Nuclear Services and Training; Finance and Administrative);
(4) Each of the Division Chiefs and their Unit Heads;
(5) General access for all employees of the Institute.

There are different discussion groups, a general discussion group for all PNRI employees, a discussion group for PNRI senior staff only, another discussion group for the Office of the Director, and a discussion group for each of the four Divisions which can be accessed only by the Division Chief, the Unit Heads and personnel belonging to the Division. Other discussion groups may be created according to the needs of the PNRI personnel through a request made to the IT group for its creation.

The PNRI intranet features a repository for documents with different levels of access. It has a repository for PNRI general documents which are available for the reference of all personnel, and which are downloadable. Examples of these documents are Office Orders, Special Orders, Administrative Orders and Executive Orders. There is a document repository for the PNRI Senior Staff, or management level document repository site. For this, only management level access is allowed, and only Senior Staff can view or post documents. There is a separate repository for documents from the Office of the Director as well as a repository for each of the Divisions at the Division and Unit level. The knowledge base resources repository contains the knowledge management documents. From the mission and vision of the Institute, the knowledge map of the PNRI has the following domains or main categories of knowledge: nuclear research; nuclear regulations and licensing; nuclear services and facilities; international linkages and training; planning and internal audit; finance and administration; and the IMS documents. Critical knowledge in these domains will be stored in the knowledge base resources and shared within the PNRI through the intranet.

The integrated on-line services ('E-Services') feature of the intranet is still under development, but once completed, will provide downloadable PNRI official forms, finance and administrative services, such as on-line tracking of requisitions for office supplies, purchase requests, document tracking and other services.

4. NETWORKING AS A KNOWLEDGE MANAGEMENT STRATEGY

The PNRI is participating in regional networks, which aim to preserve and share nuclear knowledge, including the ANSN, the Asian Network for Education in Nuclear Technology (ANENT) and the Forum for Nuclear Cooperation in Asia (FNCA). ANSN has the objective of pooling, analysing and sharing existing and new technical knowledge and practical experience to further improve the safety of nuclear installations in Asia. PNRI participates in communities of practice through the ANSN's topical groups on education and training, safety analysis of research reactors, etc. ANENT is a new regional partnership, supported by the IAEA, for cooperation in capacity building, human resource development and scientific research in nuclear technology. ANENT is set up to promote, manage and preserve nuclear knowledge and to ensure the continued availability of talented and qualified human resources in the nuclear field in the Asian region and to enhance the quality of human resources for the sustainability of nuclear technology. The major participation of the PNRI in ANENT activities is in distance learning or distance education in nuclear science and technology. The FNCA is an initiative for regional cooperation in nuclear science and technology sponsored by Japan. Under this framework, cooperation and information exchanges are made in the following fields or subprojects:

(1) Utilization of research reactors;
(2) Utilization of radioisotopes and radiation in agriculture;
(3) Application of radioisotopes and radiation for medical use;
(4) Public information of nuclear energy;
(5) Radioactive waste management;
(6) Safety culture of nuclear energy;
(7) Human resources development and other new subprojects.

Other initiatives of the National Government and of the Department of Science and Technology indirectly support the knowledge management initiatives of the PNRI. Through the Philippine e-Library or eLib project, the PNRI is interconnected with the National Library, and other libraries of government universities. In connection with this project, some library holdings of the PNRI have been digitized and made available on-line. Another network, the DOST Science and Technology Information Network of the Philippines (ScINET-PHIL) is a consortium of libraries and information centres of the 21 agencies under the DOST, which promotes information sourcing and sharing in the DOST system. The Internet connectivity of the PNRI is through a wireless connection to the PREGINET, a nationwide broadband network that links 90 academic, government and research institutions.

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Knowledge Management for Nuclear Industry Operating Organizations, IAEA-TECDOC-1510, IAEA, Vienna (in preparation).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities Safety Requirements, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities Safety Guide, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

[4] S. DENNING, "Knowledge sharing at the World Bank", Managing Nuclear Knowledge: Strategies and Human Resource Development (Proc. Conf. Saclay, 2004), IAEA, Vienna (2006).

A PORTFOLIO OF KNOWLEDGE MANAGEMENT INITIATIVES TO DERIVE BUSINESS BENEFIT

A. JACKSON
Reactor Services Group,
AMEC NNC Limited,
Cheshire, United Kingdom

Abstract

The ability to develop and maintain the specialized skills and related expertise required by the United Kingdom industry for the operation of existing units and beyond is a major concern to AMEC NNC and its partners in the nuclear community. The paper provides a summary of some of the knowledge management initiatives undertaken by AMEC NNC over the last few years, as presented at the conference, with emphasis on an integrated approach to training and development; development of a qualifications and experience register; retention of corporate knowledge through documentation; modelling techniques to capture process knowledge; and establishment of communities of practice. AMEC NNC applies a holistic approach to the application of knowledge management within the organization and has used and developed knowledge management techniques and tools to safeguard its intellectual assets and ensure that maximum innovative value is obtained from its staff.

1. INTRODUCTION TO AMEC NNC

AMEC NNC Limited, a wholly owned subsidiary of AMEC plc, is a leading international engineering, technical and project management consultancy, dedicated to adding value to clients' businesses through the provision of leading-edge professional resources. As the United Kingdom's premier dedicated nuclear services company with an annual turnover exceeding £60 million, it is committed to delivering cost effective engineering solutions and safety consultancy services. AMEC NNC has also used its wide portfolio of skills to develop non-nuclear business, particularly in the defence, environmental, and oil and gas industries, to provide solutions to complex engineering problems. The vision of AMEC NNC is to:

— Take a leading role in the United Kingdom environmental and cleanup industry;
— Be a world player in reactor services;

— Be the premier supplier of technology, radiological and environmental solutions to a wide range of nuclear and non-nuclear clients;
— Be positioned to play a leading role in future new reactor-build programmes.

AMEC NNC has its headquarters in Knutsford, Cheshire. Other offices in the United Kingdom are situated in Warrington, Cumbria, Gloucester and Thatcham. These offices are strategically placed, close to the main rail, road and air links, making AMEC NNC easily accessible to its clients. Additional offices are located at the key clients' sites, including Dounreay, Harwell, Aldermaston and Winfrith.

Clients are provided with a single multidisciplinary organization, capable of providing a wide range of skills necessary for the successful completion of any decommissioning, plant enhancement or refurbishment projects, including:

— Remote operations;
— Instrumentation and control (I&C);
— Safety assessment and reliability;
— Shielding;
— Personnel radiological protection and control;
— Decommissioning;
— Environmental impact management consultancy;
— Technical documentation;
— Monitoring and alarm systems;
— Project management;
— Structural analysis;
— Reactor services;
— Chemical, physical and radiochemical testing;
— Knowledge management solutions;
— Quality assurance (QA) and business process management.

AMEC NNC employs approximately 1000 staff, the majority of whom are professionally qualified chemical, mechanical, electrical and structural engineers, as well as chemists, physicists and stress analysts.

Many of its consultants are highly respected international authorities in their fields. AMEC NNC has proven problem solving ability, and an approach that integrates technical excellence with practical and cost effective solutions.

2. FORMULATION OF A HOLISTIC KNOWLEDGE MANAGEMENT STRATEGY IN AMEC NNC

AMEC NNC has a holistic approach to knowledge management as represented by Fig. 1. AMEC NNC combines the hard (IT related) and soft (people related) aspects into an integrated approach that in most organizations is executed in ‘silos’ by separate department groups.

In terms of targeting specific knowledge management improvement areas, AMEC NNC has carried out benchmarking activities with other organizations inside and outside the nuclear sector. A formal gap analysis based on the results of this work has been instrumental in providing the basis for AMEC NNC’s ongoing knowledge management development programme.

The sections that follow represent some of the knowledge management initiatives undertaken in AMEC NNC to date.

3. INTEGRATED APPROACH TO TRAINING AND DEVELOPMENT

AMEC NNC operates in the nuclear and defence sectors, where compliance with public and personal safety issues is regarded as a key ingredient to all activities undertaken from concept design through to construction, operation and eventual decommissioning of nuclear facilities. In the United Kingdom nuclear sector, the independent government regulator is

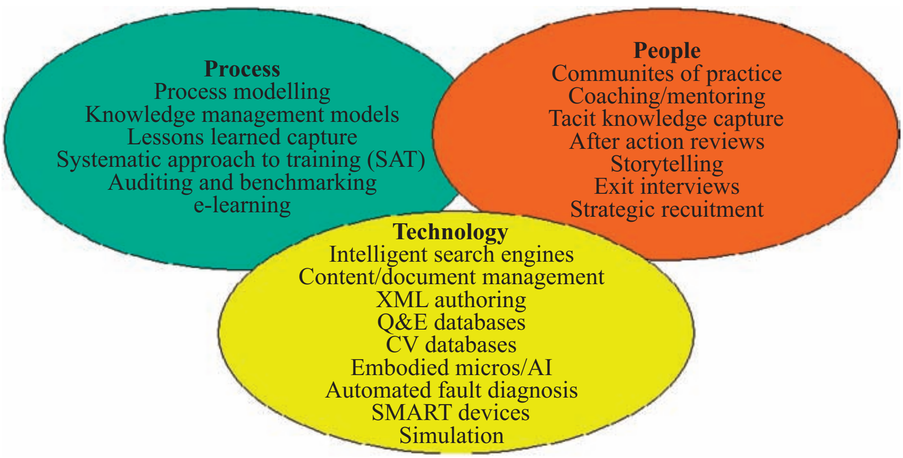

FIG. 1. NNC holistic view of knowledge management areas.

the Nuclear Installations Inspectorate (NII) and, as part of the licensing conditions for nuclear sites, it is a requirement to demonstrate that key operating and supporting staff are ‘suitably qualified and experienced people’ (SQEP). The SQEP requirement has a similar impact on the supply chain supporting nuclear operations at site and suppliers are also required to demonstrate that its staff is suitably qualified and experienced.

Based on the background mentioned, AMEC NNC has focused its training and development activities in support of the SQEP requirement and has adopted a systematic approach to training throughout the organization covering the following areas:

(a) *Analysis:* To determine training needs and the competencies required to perform a particular role. Closely related to this is the analysis of current and future workloads that are likely, based on client requirements and demands.
(b) *Design:* Based on training needs, individuals are encouraged to organize their own training objectives and development plan.
(c) *Preparation:* The preparation of training materials to meet the training plan. This may also involve the identification of external training providers.
(d) *Implementation:* During this phase training is conducted by using the internal training materials developed or external resources.
(e) *Evaluation:* Benefits analysis to ensure that training is cost effective and meeting the training needs.

Other training and development strategies include:

— A targeted graduate recruitment and training programme;
— Coaching and mentoring for all younger staff under 25 years of age;
— Encouragement for all staff to gain professional qualifications, such as Chartered Engineers or Scientists.

In summary, this integrated approach to training and development ensures that SQEP staff is assigned to appropriate project tasks and sufficient numbers of SQEP staff are available for current and projected project needs.

4. DEVELOPMENT OF A QUALIFICATIONS AND EXPERIENCE REGISTER

Many organizations have a poor understanding of the skills, experience, qualifications, etc. that their staff possesses. Some organizations use a database of CVs or provide staff profiles via their intranets. This project to develop a ‘qualifications and experience’ register was conceived to provide an enterprise solution to assist in the identification and communication of skills and competencies and to support the SQEP requirement as outlined in the previous section.

The specific business problems and the project addresses are listed below:

(1) Identifying and capturing qualifications, skills and experience for all staff in all locations worldwide to demonstrate staff members are competent in support of activities in the nuclear sector.
(2) Providing evidence that staff members are competent and experienced in the skill areas claimed.
(3) Sharing information about staff skills and competencies for use throughout the organization in all locations.
(4) Integrating skills information with other related issues, such as training and development, CVs and academic and professional qualifications.
(5) Providing a process and a system that is easy to use by all staff and hence requiring minimal training.

AMEC NNC’s initial strategy was to locate a system ‘off the shelf’ that would do the above but market research showed that there was no such system available that would meet all the necessary requirements. A development programme was thus established with a team leader and a small number of support staff to design and implement a process and system from first principles.

Following a two year study and implementation programme, a competency based taxonomy for identifying qualifications, skills and experience was successfully created and implemented across the enterprise with details of over 1000 staff captured. The solution, known as the qualifications and experience register (Q and E), is regarded as one of the key knowledge management tools of the organization allowing particular expertise to be quickly located.

The diagram (see Fig. 2) outlines in summary form some of the main interfaces and flows while using the Q and E register.

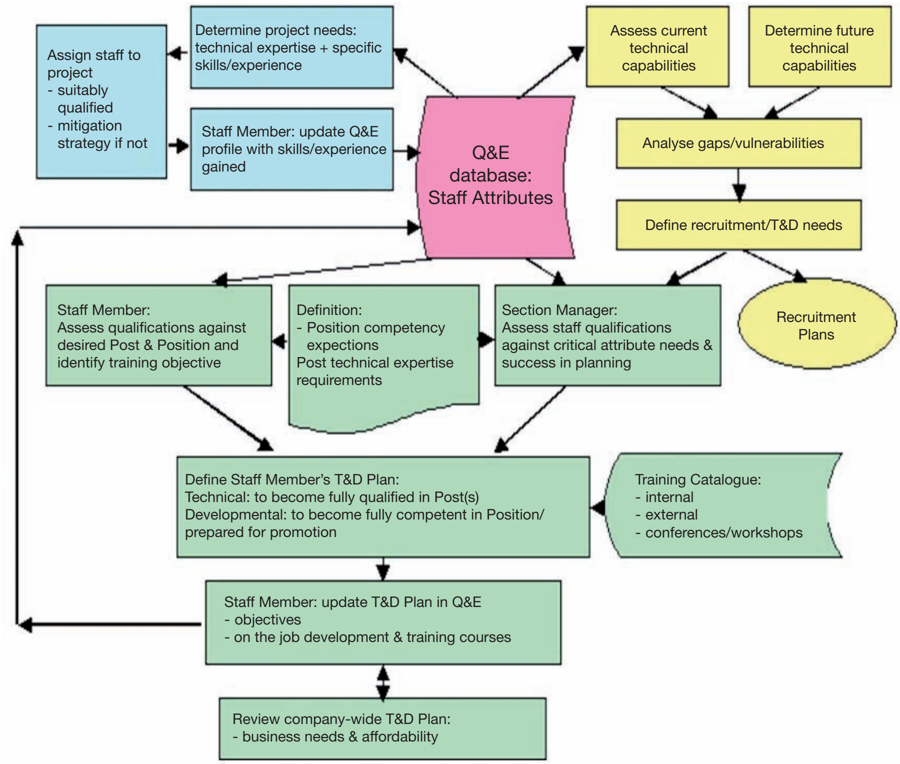

FIG. 2. Qualifications and experience (Q and E) register — functional flow diagram.

Table 1 defines the main areas where each staff member interfaces with the database.

In terms of project benefits, the Q and E register has successfully addressed the business problems identified earlier in this section and is now used throughout the organization for competency identification and as a tool for personal development.

5. RETENTION OF CORPORATE KNOWLEDGE THROUGH DOCUMENTATION

In making decisions to support safe nuclear operation, it is essential that accurate records be kept to provide the basis for such decisions and to capture the design rationale existing at the time. For many years now AMEC NNC has

TABLE 1. STAFF INPUT REQUIREMENTS AND DEFINITIONS

Area	Definition
Technical discipline	The main technical disciplines for staff (e.g. mechanical, electrical, safety, IT, QA, etc.)
Skills	Particular areas and sub-areas of expertise within the technical discipline
Experience	Industrial sectors (e.g. nuclear, defence, aerospace, automotive, etc.) and for nuclear, the types of reactor system and locations worked
Level of competence	Six levels of competence for each skill from international expert to basic knowledge
Academic qualification	University and school qualifications for the United Kingdom awarding bodies
Professional qualification (chartered status)	Levels of award (e.g. C. Eng, fellow, member, associate member, etc.) for all recognized professional institutions
Client awarded qualification	Client specific awards and accreditations
Understanding of regulatory requirements	Licensing regulations and standards experience

put in place processes and systems to support the retention of this explicit knowledge, viz.:

— Calculation notes and work files to support analysis tasks;
— Registries to capture correspondence and project information;
— Electronic content management systems to capture information (reports, drawings, analytical data, etc.);
— Corporate and local intranets to support general information management.

Processes relating to document management and preservation are considered core activities within AMEC NNC. Line management activities are important here to ensure compliance so that information can be easily located and retrieved.

The main benefits resulting from this strategy have been:

— Winning business from customers who benefit from AMEC NNC's archive of information, supporting the completion of their projects;

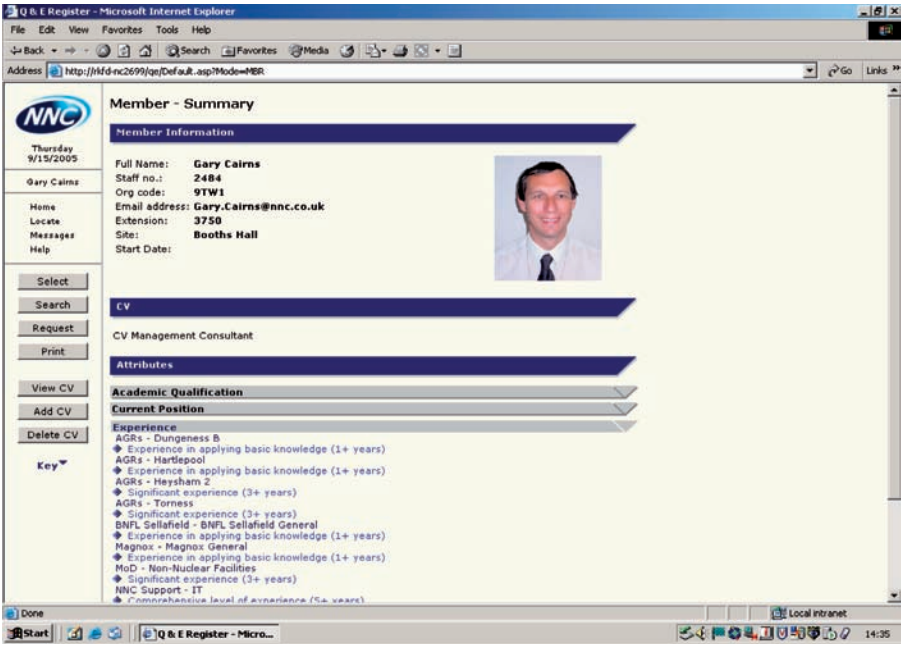

FIG. 3. Q and E register — screenshot of typical staff summary information.

- — On new projects, non-propriety information from previous similar projects has been reused. Ready access to this information provides the ability to review previous methodologies and consider their relevance to this project as 'best practice', supporting the goal of a fit for purpose output;
- — To provide a training and development focus for new staff who have used retained information and know-how to develop new competencies.

6. MODELLING TECHNIQUES TO CAPTURE PROCESS KNOWLEDGE

In addition to subject knowledge, 'process knowledge' relating to how, why, who and what, is expected of staff and the way they work in support of the organization is regarded as a core competency in AMEC NNC. Previously, this knowledge and the supporting explicit knowledge held by technical experts was distributed among technical experts within the organization, via an array of manuals and other documentation that made it difficult to find and utilize. To help staff better understand internal processes and to provide insight into best practice, AMEC NNC has remodelled its entire process architecture and moved away from the conventional reliance on manuals for QA, engineering and similar activities. In AMEC NNC today, there exits a number of cascading process models available on the corporate intranet that have process knowledge 'embedded' by the use of attached guidance notes. This top-level process model is shown in Fig. 4. (It is important to note the process owners given below have changed since this diagram was produced.)

By moving towards a process, rather than a pure documentation structure, AMEC NNC has been able to encourage knowledge sharing and best practices and has taken away the tedium for staff having to read and digest large amounts of information in the form of traditional manuals.

7. ESTABLISHMENT OF COMMUNITIES OF PRACTICE

Communities of practice (CoPs) represent the formation and bringing together of like-minded people to discuss and share knowledge typically

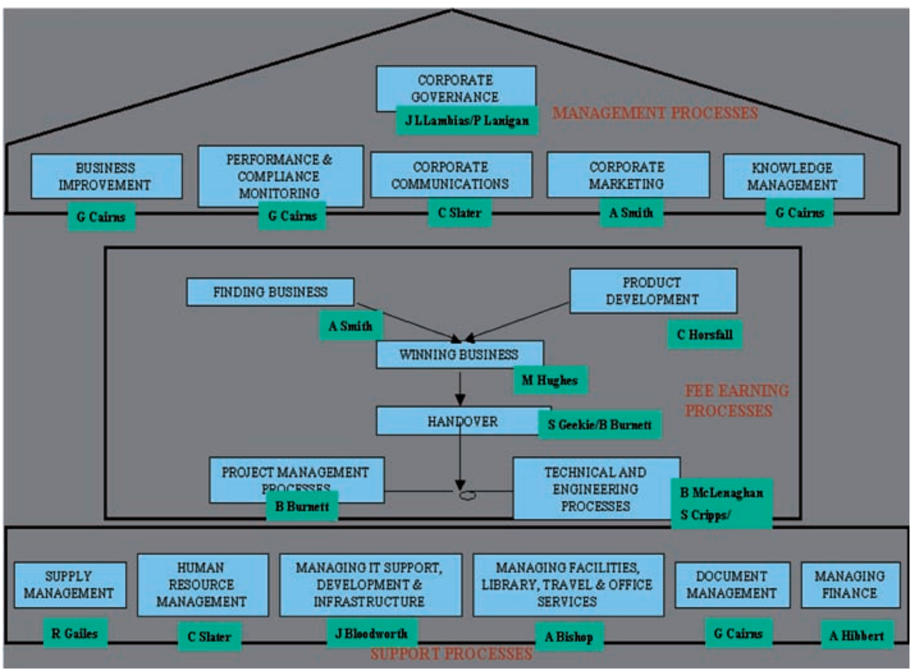

FIG. 4. Top-level process model.

centred upon a specific discipline area. In AMEC NNC, CoPs have been established for the following groups:

- Mechanical engineering;
- I & C;
- Process engineering;
- Civil engineering;
- Chemistry/materials;
- Physics;
- Safety;
- Procurement;
- Tendering;
- Project management.

Each CoP is led by a head of profession, whose terms of reference include establishing best practice, conducting individual performance reviews, leading discussion groups and workshops, and sharing lessons learned. Sessions are generally held every month with a mix of formal and less formal approaches.

A unique feature of CoPs in AMEC NNC is the concept of extending the community to the customer wherever possible. The main benefits of implementing a CoP approach within AMEC NNC have been:

- More effective collaboration and the formation of strong relationships with existing clients which has helped to secure existing work and new work.
- Accountability for the development of discipline processes and best practice.
- To develop an open culture of knowledge sharing between staff.

8. SUMMARY AND CONCLUSION

In the last four or five years, AMEC NNC has focused its main business improvement activities around the development of processes and systems to support knowledge identification, utilization, communication and preservation. The organization has learned to appreciate that the implementation of a well orchestrated knowledge management programme is a key driver to the organization's success that can deliver real tangible benefits.

AMEC NNC uses a holistic approach to the implementation of knowledge managment initiatives, realizing that many improvements can be achieved without the need for a large investment in IT or its supporting infrastructure.

In terms of ongoing and future knowledge management programme activities, AMEC NNC will be focusing on:

— Continuous improvement of these tools;
— Further development of tacit knowledge capture and transfer application;
— Succession planning;
— Lessons learned feedback;
— Knowledge audit and concept mapping.

AMEC NNC recognizes that knowledge management is a complex, expensive but vital function for the continuing success of its business and as an organization it strives to retain past knowledge in a recallable and readily usable form, thus supporting the development and maintenance of the necessary skills for current and future industry needs. AMEC NNC is actively developing new strategies, processes and systems to deliver business benefit throughout the organization.

MANAGING NUCLEAR INFORMATION RESOURCES

(Session 2)

Chairperson

A. TOLSTENKOV
IAEA

INTERNATIONAL NUCLEAR INFORMATION SYSTEM
Thirty-five years of successful international cooperation

A. TOLSTENKOV
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

The International Nuclear Information System (INIS), established in 1970, has been growing in a spectacular manner over the years. Its current membership includes 114 Member States and 20 international organizations. The products and services of INIS and its future development as a knowledge management tool are briefly described in the paper.

1. INTRODUCTION

The International Nuclear Information System (INIS) was established in 1970 as the international mechanism for exchanging information in the fields of peaceful uses of nuclear sciences and technology. International cooperation and decentralization are the distinguished features of this system, which allow achieving maximum coverage, overcoming cultural and language barriers and giving every INIS member the right to access the relevant nuclear information of all other INIS members.

When INIS was established, it had a total of 25 members, including countries and international organizations. Since then, a spectacular growth has taken place in membership with 114 Member States and 20 international organizations participating in INIS today. This increase in membership, mainly from developing countries, demonstrates the growing interest in nuclear technology and applications with growing economic and social development. In recent years INIS has been developing as an efficient mechanism for the exchange of information between Member States and the preservation of their nuclear knowledge. It provides a comprehensive information reference service for publications and other types of literature in the nuclear field and the corresponding full texts of non-conventional or grey literature.

2. INIS PRODUCTS AND SERVICES

Based on the information received from Member States, INIS produces several high quality products including the following and makes them available to all of its members:

— The *INIS bibliographic database*, which covers the period from 1970 to the present, contains over 2.6 million indexed references with English abstracts. Recognizing the different needs of users in countries with different information technology infrastructures, the INIS database has been made available on two different platforms:
  - The *INIS database on CD-ROM*, produced since 1991, uses the Silver Platter retrieval engine. It is currently distributed on nine CD-ROMs and updated on a monthly basis. The product can be used on a standalone PC as well as through a network.
  - The *INIS database on the Internet*, launched in 1998, is the most important of all INIS products in terms of the number of subscriptions and usage. The application has a set of features, including separate user interfaces to accommodate different user requirements and levels of expertise, and access to the INIS authority lists and to the INIS thesaurus. The database is updated weekly and provides hyperlinks to a large collection of full texts, including parts of the INIS non-conventional literature (NCL) collection, and to national document delivery centres.

— The *INIS NCL collection*, which consists of two main parts:
  - The *INIS NCL archive on microfiche*, which comprises over 500 000 documents and covers the period 1970–1996;
  - The *INIS NCL collection in electronic form*, which contains over 250 000 documents and covers the period 1997–2005. The *INIS NCL collection in electronic form* is currently being linked to the *INIS Database on the Internet* to provide users with direct access to the full text directly from their computer. It is also available through the INIS NCL document delivery network. This network includes 58 INIS national document delivery centres. Over 30 000 individual requests for NCL documents are handled via this network annually.

Recognizing the advantage of having the NCL full text collection in electronic form, INIS has recently started to digitize the INIS NCL microfiche archive of full texts covering the period 1970–1996, and plans to complete the project within four to five years. The result of this project will be a full text searchable database containing over 700 000 documents.

3. FUTURE DEVELOPMENT OF INIS

Although its methods of collection and distribution have constantly evolved, the mission and objectives of INIS, within the IAEA environment, have remained practically constant since 1970. Their main focus has been on the production and distribution of the INIS database as the single largest bibliographic database on scientific and technical information in the world covering the nuclear field. However, over the years, the political and technological environments that led to the creation of INIS have radically altered. The user base has changed due to a general disaffection with nuclear power technology in highly developed Western countries counterbalanced by a growing interest in developing countries. The emergence of a global telecommunication infrastructure and the creation of the Internet have also changed the technological environment beyond recognition, leading to the emergence of a range of users' needs and expectations that did not exist earlier.

The accumulated changes in the supply and demand for nuclear information, as well as in the characteristics of the users and the user requirements for nuclear information are some of the important drivers for developing a strategic framework for future INIS development. At present INIS does not cover fully all the nuclear related information. The database does not contain certain types of information that are complementary and often significant for knowledge workers. For example, INIS does not preserve detailed designs, performance data and indicators of nuclear facilities; nor industry reports and information on nuclear experts, etc. A future strategic objective of INIS could be to preserve, enlarge and develop the scientific and technical information and knowledge resources on the peaceful use of nuclear energy to service the needs of Member States and the IAEA.

INIS is also becoming a major contributor to IAEA knowledge management activities. While INIS will continue to preserve nuclear scientific and technical information for future needs, it will evolve into a comprehensive knowledge repository by adding access to full text resources from the NCL collection and from other available electronic resources in cooperating centres and on the Internet. This is especially important with regard to accessing the knowledge that resulted from the initial and historical investment in nuclear research (e.g. space nuclear applications, earlier reactor concepts, fuel cycle concepts, etc). To accomplish this objective, INIS is developing and implementing an archiving and preservation programme for nuclear documentation. The INIS thesaurus has been identified as a major tool for the organization of and access to this knowledge.

Developing direct and indirect access to appropriate new nuclear information sources outside of the IAEA and facilitating external access to

INIS/IAEA information are other important areas for INIS development. Further enhancement of the partnership with the OECD Nuclear Energy Agency and the Energy Technology Data Exchange (ETDE), as well as other relevant international organizations in the nuclear information field, will help create new synergy and enhance the usage of INIS. The ultimate goal of INIS is to become an ‘international nuclear information and nuclear knowledge broker’ for the Member States by providing access to resources that are created and maintained by other organizations, and facilitating outside access to IAEA nuclear information and the knowledge base for the peaceful use of nuclear science and technology.

EXPERIENCE WITH KNOWLEDGE MANAGEMENT AT GRS – PART 1
Documentation and information management

D. BERAHA
Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS),
Munich, Germany

Abstract

Recognition of the imminent loss of knowledge due to the forthcoming retirement of several experts was the starting point for knowledge management activities at the GRS. In 2001, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety sponsored a project to develop the concept for a knowledge management system that would cover a network of several German organizations. At the end of the project, setting up such a knowledge management system was judged to be too ambitious and a decision was taken that GRS should implement knowledge management on its own. Subsequently, the results of its implementation would be evaluated with respect to its expansion to cover the network of organizations in a later phase. Consequently, GRS initiated a knowledge management programme in 2002. The development of a document and information management system as a part of the overall knowledge management system is described in the paper.

1. INTRODUCTION

Different models exist for describing knowledge management in an organization. GRS has adopted a simple model that covers all stages of knowledge management activities.[1] The model groups the activities on two levels:

(1) A strategic level;
(2) An operational level.

---

[1] GILBERT, J.B., RAUB, S., ROMHARDT, K., Wissen managen: Wie Unternehmen ihre wertvollste Ressource optimal nutzen, Probst, Frankfurter Allgemeine Zeitung-Verlag, Frankfurt a.M. (1999).

On the strategic level, the formulation of the knowledge goals is the indispensable first step. The operational level aims at realizing these goals by identifying, acquiring, developing, disseminating and deploying knowledge. Once a system is in place, an assessment should take place on the strategic level to enable feedback for correcting and improving the knowledge goals and thus close the loop.

The GRS goals, initially defined, were maintaining and transferring competence. Another goal was added after the first cycle of experience, which was that knowledge management should become part of the work processes and thus be integrated in everyday work.

An information and document management system had to be put in place as a prerequisite to achieve the knowledge management objectives. Such a system should collect the information and the documents dispersed in a wide variety of file-shares, databases and Internet sites, and should allow fast retrieval using different search criteria. One of the main benefits of such a system would be that documents would be retrievable from a defined place, which is a necessary requirement for building information management systems on top of the document management system.

2. DEVELOPMENT OF THE GRS PORTAL

A decision was taken to benefit from enterprise portals that have experienced considerable development. Such a portal would not only offer the necessary functionality, but also specific features suitable for improving cooperation and communication across the entire organization, two characteristics essential to knowledge management. The portal was then established through the use of Microsoft's 'sharepoint portal server', which was found particularly suitable for a medium-sized organization such as GRS. The portal provides a central access point to all documents and information. The document management features are user friendly and include 'check-in/check-out', versioning, addition of profile data (metadata) and import of mail. External file-shares and particularly the legacy databases built on Lotus Notes may be searched and indexed and the integration with MS Office 2003 is very good.

The portal also contains sites with news that are compiled from different sources, such as existing collections, Internet sources, and news on the GRS portal and its contents. It covers important topical themes in a horizontal structure such as 'Yellow Pages', quality management, organization handbook and many more. Vertically, every organizational unit has its own pages for presenting its activities. For collaboration, open team sites accessible to everybody have been set up for departments, projects and particular areas, such as emergency response and strategic programme groups. Closed team sites are accessible only to the team members and are often set up for short term collaboration on restricted fields.

In order to cater to project management requirements, the portal has been enhanced by a project server, combining 'sharepoint' team sites with MS Project. In the project server, each project has its own team site, either in German or English, with the option for project planning with MS Project. All documents relevant to the project (including email) should be entered into the portal by the project leader and his team. A default set-up of the site contains document libraries for working documents and quality assured documents, an event list, and links and contacts areas. The access rights are predefined, according to the roles played by the administrator, project leader and team members.

An important requirement of a portal is the ease of retrieving information. In this regard, the search interface provided in the portal had to be improved by a third party product to enable using Boolean, metadata and wildcard criteria to search over all portal and non-portal (external sources) content. The use of the portal is further facilitated by extensive alerts, which the user may set on libraries and lists to be notified when new information is introduced into the portal or when information is changed.

The tools which GRS has chosen for representing and modelling knowledge, namely 'concept maps' and 'ontologies' have been integrated into the portal. Apart from managing information and documents, the portal achievements should be of much wider reach. It should:

(1) Encourage the transition from email based communication to team communication in order to avoid the serious drawbacks in distributing documents by email (keeping track of the edited copies of documents, sending them to each team member for their comments on the changes made by other team members and producing a master document is often highly cumbersome, whereas a team platform with document control and versioning enables the collaboration of the team on a single master document);
(2) Improve the internal communication, e.g. by coordinating teamwork with task and event lists, and notifying users of general GRS issues;
(3) Build a corporate memory;
(4) Reinforce the acceptance of knowledge sharing.

The portal has been operational for two years and the lessons learned regarding the implementation of document and information management include the following:

(1) *Acceptance*: Although there is strong support for all knowledge management activities from the General Manager, middle management tends to be indifferent though rarely negative. The transition in the sharepoint portal server from version 1 to version 2 had an adverse effect on many users as the two versions are substantially different in architecture and user interface. The employees are not favourably inclined to the use of training and help documents available with the programme.

(2) *Yellow Pages*: The public information entered into the Yellow Pages is taken from an existing database and is consistent with that on the files of the employees as all information is, by agreement with the syndicate, entered voluntarily. However, employees are reluctant to offer information on their career and skills voluntarily as indicated by the fact that only about 30% of the staff offered such information.

(3) *Document management*: The most important success has been the setting up of a portal for each project on the project server. The guidelines issued on the structure and utilization of the portals was very helpful and the number of documents in the portal has been steadily increasing. On the down side, even the simple version poses problems to some users and the description of the documents by metadata is too onerous for most users.

(4) *Information retrieval*: Provisions for full text search, search on particular sources and on metadata are significant improvements in retrieving the information requested. However, the ranking of documents is not always satisfactory and too many hits are produced. Current efforts in structuring and categorizing knowledge domains appear to be improving the situation.

(5) *Collaboration*: The number of teams drawing benefit from team sites has been continuously increasing. However, email continues to be the most important means of communication.

3. CONCLUSIONS

Information and guidelines on the contents and the utilization of the portal have to be better conveyed to the employees by the management through identifying key persons in a knowledge management community, intensifying training and demonstrating successful examples.

The rapidly increasing quantity of information in the portal poses problems with respect to navigation and retrieval and should be improved. It is evident that increasing the quality of retrieval will require significant additional efforts in areas such as generating structures, improving metadata, deploying methods of knowledge representation, and modelling with taxonomies and ontologies. Semi-automatic systems for categorization are continuously improving and should be given serious consideration.

For the future, plans are being developed to establish a similar portal for several organizations operating in the nuclear field, thus coming back to the original idea of an inter-organizational knowledge management network.

PRESERVATION OF INFORMATION AND RECORDS

A. TOLSTENKOV
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

Digital technology offers distinctive advantages in the preservation of knowledge and information. The power of full text searching, sophisticated cross-collection indexing, newly developed system interfaces, new ways to deliver manageable portions of large image data files promise to revolutionize the ways in which research materials are used for teaching and learning. The required investments for digitization and digital preservation are quite large. Metadata, often called data about data or information about information, are the key to ensuring that resources will survive and continue to be accessible to future users. The nature of the physical media on which digital data are stored presents a serious challenge to the preservation of digital content. The main technologies for storing and maintaining information are briefly described in the paper.

1. INTRODUCTION

The problem of the preservation of knowledge and information is extremely wide and it is very difficult to discuss all its components in a brief presentation. This paper outlines only the problem of digital preservation. Digital technology offers distinctive advantages to institutions with impressive collections of information resources. Information content can be delivered directly to the reader without human intervention. Digital quality is extraordinary and is improving constantly. It is now possible to represent almost any type of traditional research material with such visual quality that reference to the original materials is unnecessary for most, if not all, purposes.

The power of full text searching and sophisticated, cross-collection indexing affords readers the opportunity to make new uses of traditional research resources. Newly developed system interfaces combined with new ways to deliver manageable portions of large image data files promise to revolutionize the ways in which research materials are used for teaching and learning. Nevertheless the required investments for digitization and digital preservation are quite large.

2. DIGITAL PRESERVATION OF INFORMATION

Digital preservation requires a deep and longstanding institutional commitment to traditional preservation, full integration of the technology with information management processes, and significant leadership in developing adequate definitions and standards. It encompasses a broad range of activities designed to extend the usable life of machine-readable computer files and protect them from media failure, physical loss and obsolescence.

The main goals of digital preservation are to:

— Select the most valuable information to convey to the future;
— Ensure that it remains readable, accessible and understandable;
— Manage technological change so that those objectives are met.

Usually any process of knowledge and information preservation consists of several important steps: select and capture information; describe information (assign metadata); store information; provide access to information; and ensure its longevity. Most organizations lack the resources to digitize and maintain their entire information collection and, in such a case, the prioritization and selection of items of information to be digitized becomes essential. It is necessary also to stress that digital information comes with a 'mortgage' — each organization has to make budget provisions to transfer old files to new formats as software and hardware change and electronic media reach the end of their relatively short life. Another reason for the selection of information items to be digitized relates to legal issues. Organizations often lack intellectual property rights and permissions for the information materials they have. Digitization without thoughtful selection may result in the creation of digital objects that can not be effectively used due to legal restrictions. Determining the legal status of candidate materials is a crucial step in any digital selection process.

3. METADATA

The next important step after selecting and digitizing information is the description of information or creating and assigning metadata, which are structured kinds of information that describes, explains, locates or otherwise makes it easier to retrieve, use or manage an information resource. Metadata are often called data about data or information about information. They are the key to ensuring that resources will survive and continue to be accessible to future users.

There are three main types of metadata:

— Descriptive metadata describe a resource for purposes, such as identification and recovery. It can include elements, such as title, abstract, author and keywords.
— Structural metadata indicate how compound objects are put together, for example, how pages are ordered to form chapters.
— Administrative metadata assist in managing a resource by providing information, such as when and how it was created, file type and other technical information, and who is allowed to access it.

Metadata can describe resources at any level of aggregation. They can describe a collection, a single resource or a component part of a larger resource (for example, a photograph in an article). An important reason for creating descriptive metadata is to facilitate recovery of relevant information. In addition to resource recovery, metadata can help organize electronic resources; facilitate interoperability and legacy resource integration; provide digital identification; and support archiving and preservation. Describing a resource with metadata allows it to be understood by both humans and machines in ways that promote interoperability, which is the ability of multiple systems with different hardware and software platforms, data structures and interfaces to exchange data with minimal loss of content and functionality. Using defined metadata schemes, shared transfer protocols and crosswalks between schemes, resources across the network can be searched more seamlessly.

Metadata schemes are sets of metadata elements designed for a specific purpose, such as describing a particular type of information resource. There are many metadata schemes but the Dublin Core metadata scheme is the most popular and is a de facto market standard. The original objective of the Dublin Core was to define a set of elements that could be used by authors to describe their own information resources. The Dublin Core includes 15 core elements: Title, Creator, Subject, Description, Publisher, Contributor, Date, Type, Format, Identifier, Source, Language, Relation, Coverage and Rights. INIS has developed the structure of metadata elements based on XML technology.

4. INFORMATION STORAGE

Digital information together with assigned metadata have to be properly stored. The nature of the physical media on which digital data are stored presents a serious challenge to the preservation of digital content. The great variety of media types, their often rapid obsolescence due to technological change, and their vulnerability to physical degradation, all contribute to the problem. There are three commonly used categories of digital storage media: disk (magnetic fixed and removable hard drive, floppy, zip, magneto-optical, optical, etc.); tape (open reel, cassette, cartridge); and solid state (USB memory stick, flash drive, etc.). Within each subcategory, there may be numerous variations in physical size and configuration, storage capacity and materials. No computer storage medium can be considered archival, irrespective of its physical longevity, since technological obsolescence is inevitable. The need to periodically refresh electronic records on to new media is inescapable for the foreseeable future. Nevertheless, careful selection of appropriate media can maximize the periods between refreshment cycles and simplify the refreshment process, in addition to providing the securest storage environment possible.

As mentioned, one of the main goals of digital preservation is to ensure that information remains readable, accessible and understandable. The system must be able to find and deliver digital objects effectively in response to end user requests. Preservation without the means of access is of negligible value and access remains one of the primary purposes of a preservation system. Access generally demands the use of the current technology to render information that will meet user expectations. The managerial challenge is to ensure that the requirements to deliver can be met, that the user communities are well defined, and that adequate resources are available to support ongoing development in support of easy access.

5. MAINTAINING DIGITAL INFORMATION

With a large volume of information being committed to conversion into digital form, it is extremely important to ensure that digital information will continue to be readable and understandable over a prolonged period of time. Unfortunately there are many examples when large bodies of digital information have been lost due to the deterioration of magnetic media. But the problem of storage media deterioration pales in comparison with the problems of rapidly changing storage devices and changing file formats. It is almost impossible today to read files from 8 in. floppy disks that were popular 20 years ago or to decode WordStar files. It is necessary to maintain digital information in order to prevent information loss due to technological changes and to minimize the problems of digital longevity.

Refreshing, migration and emulation are the three main technologies for maintaining digital information:

— Refreshing involves copying content from one storage medium to another. As such it targets only media obsolescence and is not a full service preservation strategy. An example of refreshing is copying a group of files from CD-ROMs to DVDs. Refreshing should be seen as an integral part of an enduring care policy.
— Migration is the process of transferring digital information from one hardware and software setting to another or from one computer generation to subsequent generations. Migration can also be format based, to move image files from an obsolete file format or to increase their functionality.
— Emulation involves the re-creation of the technical environment required to view and use a digital collection. This is achieved by maintaining information about the hardware and software requirements so that the system can be re-engineered.

Neither the organization nor technical infrastructures are sustainable without a continuing commitment of resources. Institutions initiating digital preservation projects have to define and demonstrate an adequate resource base that supports the processes necessary to meet project goals. Project goals, such as ensuring continuing access to vital digital assets, have to be translated into specific deliverables, such as a five to ten year preservation implementation plan.

IAEA KNOWLEDGE MANAGEMENT INITIATIVES

A. TOLSTENKOV, A. KOSILOV
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

Since its inception the IAEA has always been a knowledge based organization, requested to serve and promote the cause of peaceful use of nuclear science and technology. For nearly five decades the IAEA has been providing nuclear information and knowledge to Member States. A substantial part of the IAEA's activities under the regular budget and technical cooperation programme are aimed at developing and sustaining adequate nuclear competence in the Member States, including helping to build capacity in different aspects of the peaceful uses of nuclear energy. The paper describes some knowledge management initiatives that are being implemented within the framework of the IAEA programme on nuclear knowledge management.

1. BACKGROUND

The IAEA programme on nuclear knowledge management consists of three main elements:

(1) Developing policy and guidance for nuclear knowledge management;
(2) Facilitating sustainable education and training in nuclear science and related fields;
(3) Maintaining and preserving knowledge in specific areas of nuclear science and technology.

The overall programme is aimed at increasing the awareness and understanding in Member States, of the need for sustaining knowledge and expertise in nuclear science and technology, and effectively serving their knowledge management needs.

2. CAPTURING AND PRESERVING KNOWLEDGE AND INFORMATION

One of the main activities in the area of the preservation of nuclear information is the maintenance of the INIS NCL Full-Text Collection (http://www.iaea.org/inis/products/ncl.htm). Non-conventional literature (NCL), or ‘grey’ literature, is literature that is not available through normal commercial channels and includes scientific and technical reports, patents, conference proceedings, theses, etc.

From the very beginning, INIS understood the importance of collecting and preserving NCL documents. INIS started building this collection in 1970 and currently the collection contains over 600 000 documents and many of them cannot be found anywhere else. Over 80% of the collection consists of reports and conference proceedings written in 63 languages (Western languages: 83%; Cyrillic and Slavic: 12%; Asian languages: 4.5%; Arabic: 0.4%).

Recognizing the advantages of the availability of the NCL full texts in electronic form, INIS started the project of the digitization of the INIS NCL microfiche archive in 2002 and over 250 000 documents have been already converted into electronic form. The availability of the INIS NCL collection in electronic form facilitates the development of direct access to NCL documents via the INIS database on the Internet, as well as the establishment of the INIS NCL document delivery network (http://www.iaea.org/inis/dd_srv.htm). This network currently includes 58 INIS national document delivery centres. Over 30 000 individual requests for NCL documents are handled via this network annually.

In parallel, several projects to digitize relevant documents have been initiated in close cooperation with the Member States. Materials digitized so far include documents of the International Nuclear Data System, the historical French CEA-R microfiche collection, the IAEA Board of Governors documents, IAEA technical documents, etc.

Other initiatives to foster a direct contact between experts are the ‘Find-an-Expert’ facility and the ‘IAEA Nuclear Knowledge Desk’.

The Find-an-Expert facility (http://www-fae.iaea.org) helps experts who work on similar subjects to identify colleagues via the bibliographic records in the INIS database and to establish direct contacts. The IAEA Nuclear Knowledge Desk (http://www.iaea.org/km/nkd) facilitates a direct contact between the requester and an expert in the IAEA or by providing access to an adequate source of information.

In the framework of nuclear knowledge preservation, several subject oriented data and knowledge bases have been developed, especially the IAEA databases and web sites on the subject of 'Fast Reactors' (http://www.iaea.org/inis/aws/fnss), 'Accelerator Driven Systems' (http://www-adsdb.iaea.org) and 'Gas Cooled Reactors' (http://www.iaea.org/inis/aws/htgr). Another important aspect of corporate knowledge management activities will be the establishment of the IAEA Nuclear Knowledge Portal. A number of preparatory activities have already taken place, including two technical meetings. The first practical step in this direction was the development of the 'Annotated Internet Directory of Nuclear Information Resources' (http://www.iaea.org/inis/ws) — a growing database of annotated links to web sites on the Internet that are related to various fields of nuclear science and technology, and the IAEA's work.

In order to improve the efficiency of capturing and exchanging information within the Department of Nuclear Energy of the IAEA, the 'nuclear energy knowledge community' system has been established based on the LiveLink software. The system includes the management of inputs from all the Departments of the IAEA to the country specific briefings regularly prepared for the Director General and the maintenance of a repository of Department of Nuclear Energy travel reports. The travel reports system is fully searchable and is a well categorized collection, not only of travel reports but also auxiliary documents, such as presentations or papers by IAEA staff members during their official travels. The collection helps staff from the Department of Nuclear Energy to access the knowledge contained in those documents and facilitates staff to improve their performance of programmatic tasks.

3. KNOWLEDGE PRESERVATION AND MANAGEMENT IN NUCLEAR SCIENCE AND TECHNOLOGY IN COUNTRIES THAT ARE NOW MEMBERS OF THE CIS

Nuclear knowledge preservation has become a general issue of concern in the new countries that were former Soviet republics. Under the framework of the Commission of CIS States on the Peaceful Use of Atomic Energy, a special working group was created to conduct an estimation and analysis of the current status of nuclear knowledge preservation and management in countries that are now members of the Commonwealth of Independent States (CIS).

At present, a draft technical document on methodology for knowledge preservation and management in the CIS has been developed. The document outlines the knowledge structure in the CIS and presents a common approach to nuclear knowledge preservation, which is based on IAEA recommendations, taking into account national interests in the CIS. The document is expected to be finalized in early 2006, during a meeting in Vienna.

4. FAST REACTOR DATA RETRIEVAL AND KNOWLEDGE PRESERVATION INITIATIVE

This initiative is in response to Member States' expressed needs to maintain and increase the present knowledge and expertise in nuclear science and technology. In a nutshell, the IAEA initiative seeks to establish a comprehensive, international inventory of fast reactor data and knowledge, which would be sufficient to form the basis for fast reactor development in 30 to 40 years from now. This knowledge base is intended to provide access to the national guardians, assured quality information on basic research, design, safety, fabrication, construction, operation and decommissioning of fast reactors.

Steps already taken by various countries were reviewed, the scope of fast reactor knowledge preservation activities was clearly defined, a road map for the implementation of the initiative was outlined, and the IAEA's role identified. The IAEA is collaborating with the OECD/NEA in this area.

Extensive efforts in some countries, particularly France, Japan, the Russian Federation and the United Kingdom, are being made with regard to retrieving and preserving some important items of data from an inventory of knowledge that is continuing to be lost. The IAEA intends to develop a knowledge base into which existing knowledge preservation 'systems' will fit and within which new efforts to preserve data and knowledge will complement the past work. It would also be necessary to utilize the rapidly diminishing group of senior international experts for reviewing and interpreting the retrieved data and information in order to assure their quality.

While the responsibility for data retrieval and interpretation, as well as quality assurance will rest with the individual Member States joining the initiative, the IAEA would be responsible for coordinating national efforts, ensuring collaboration with other international organizations, and eventually establishing and maintaining the means of access to the 'fast reactor knowledge base'. In this context, 'access' means establishing a portal to the information. However, in case of proprietary data, the free exchange of some of the information between Member States may still require negotiation on a case by case basis.

More specifically, the IAEA would support and coordinate data retrieval and interpretation efforts by senior fast reactor experts in the various Member States. The most urgent tasks for these experts will be to identify the data and information that are in danger of being lost, assess its importance and relevance, retrieve and ensure its preservation.

In summary, the IAEA's initiative would provide an overall framework for the various programs being implemented in the Member States to stem the loss of data and information, retrieve data, assess their importance, identify data and information that should be retained, link information from different programs, assess the quality of information, and identify standards that should exist in software and hardware for preservation over the next 30–40 years. It would support and coordinate data retrieval activities, and establish a portal for accessing the knowledge base. By addressing issues of 'institutional memory' (e.g. retrieval and preservation of the decision making processes, including the 'false trails' followed and eventually rejected) and of passing information from one generation to the next, it aims at more than collecting information on static web based databases.

5. COORDINATED RESEARCH PROJECT: COMPARATIVE ANALYSIS OF METHODS AND TOOLS FOR NUCLEAR KNOWLEDGE PRESERVATION

The objective of a new coordinated research project (CRP) on Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservation, commencing in 2005, is to support the preservation of nuclear knowledge in Member States and the IAEA by selection and implementation of appropriate cost effective technological solutions.

The objective will be achieved through identification of alternative knowledge preservation methods and tools necessary to understand, capture, interpret, analyse, visualize, retrieve, archive and disseminate data and information, as well as the knowledge ultimately derived from them. The existing incompatibilities between data formats, software systems, methodologies, standards and models in Member States and the IAEA will require research and analysis in multiple disciplines.

Based on the result of the comparative analysis, recommendations/ solutions and benchmarks for nuclear knowledge preservation will be developed. Alternative solutions would be indicated due to the technology gap between Member States. These alternatives will facilitate interoperability, knowledge exchange and integration; improve the present understanding of various technological aspects of nuclear knowledge preservation; and increase the efficiency of nuclear knowledge preservation projects in the IAEA and Member States. The resulting technologies and applications from the CRP will be documented and disseminated both in print and electronic form.

ODIN DATABASES OF JRC–PETTEN
Useful tools for European R&D projects and international organizations

H.H. OVER, E. WOLFART
JRC Institute for Energy of the European Commission,
Petten, Netherlands

Abstract

Materials databases (MDBs) are powerful tools to store, retrieve and present experimental materials data of various categories adapted to specific needs of users. In combination with analysis tools, experimental data are necessary for activities, such as mechanical design, construction and lifetime predictions of complex components. The effective and efficient handling of large amounts of generic and detailed materials data with regard to properties related to fabrication processes, coating layers, etc. is one of the basic elements of data administration within ongoing European research projects and networks. The JRC Institute for Energy of the European Commission at Petten (JRC–Petten) has developed an Alloys database and Corrosion database for storing its materials test data resulting from in-house research some 20 years ago. Both databases have been merged to Mat-DB. Since then the database structure has constantly grown and JRC–Petten has developed the MDBs from its initial mainframe databases without graphical user guidance, over PC and client/server applications to the new web enabled interface. The Mat-DB database structure is oriented to international material standards and recommendations. PC applications are already in use at the IAEA to administer and exchange confidential embrittlement data. The JAVA based www interface and evaluation routines are further developed, improved and maintained together with the powerful server installations. Mat-DB is integrated at JRC–Petten within a secure ODIN portal (On-line Data & Information Network: http://odin.jrc.nl). Final reports of R&D projects and drawings of any format can be stored within the source part of the database. Files can also be stored as 'blobs' (binary large objects) into the database to keep track of large amounts of raw data, such as unfiltered/reduced curve data and basic output of strain gauge measurements. The whole project documentation, including minutes of meetings, can additionally be stored in a structured manner (e.g. public and confidential areas) in the document management database DoMa and linked to project specific data sets. One of the motivations for developing the web enabled database application was to provide fast access to confidential, restricted and public data sets on the Petten server and help to administer and distribute the data and documentation between European R&D partners. Just by opening their browsers they can immediately access and evaluate data sets entered and validated by one of their members. Examples are presented on how these tools are used for different applications for the benefit of other groups and international organizations such as the IAEA.

1. INTRODUCTION

In order to support European knowledge management, the Joint Research Centre Institute for Energy of the European Commission at Petten (JRC–Petten) established the Online Data & Information Network (ODIN), which is an Internet portal providing access to a number of web enabled engineering databases, document management sites and other information related to European research in the field of energy (http://odin.jrc.nl), including nuclear energy. The ODIN databases conserve knowledge obtained from European research and safeguard public investments. The main part of these databases has nuclear relevance.

2. ODIN OBJECTIVES AND FEATURES

The objectives and features of ODIN are given in Table 1. Confidentiality is provided wherever this is required for copyright reasons. Controlled access to the databases with username/password and encrypted data transfer and a professional software and hardware infrastructure (see Fig. 1), which will be maintained and upgraded, guarantee confidentiality of restricted data. For example, where European projects choose ODIN as the data management and exchange platform, access to the relevant data is restricted to the project members. The JRC–Petten, as a trusted organization without commercial interests, is the appropriate site to store these confidential project data.

TABLE 1. OBJECTIVES AND FEATURES OF ODIN

Objectives	Features
Knowledge preservation of conventional and nuclear energy related R&D	Public and restricted data content
Management and exchange of data and documentation within European R&D projects	Free of charge distribution to benefit European R&D
Dissemination of public data and information to the European research community	Deployment of professional hardware and software infrastructure
Provision of data and documentation for training and education	Central, long term maintenance of databases and applications
	English user interface

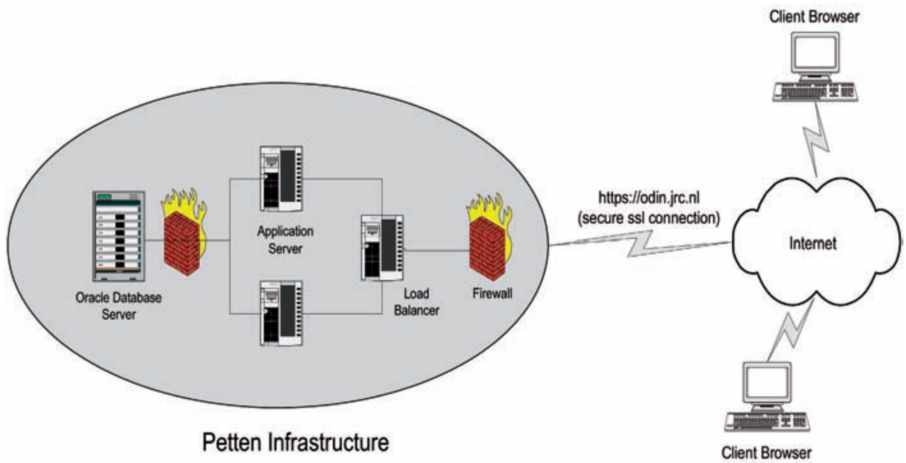

FIG. 1. Hardware infrastructure of ODIN platform.

3. OVERVIEW OF ODIN DATABASES

A brief overview of the ODIN databases is given in the following paragraphs.

3.1. Materials database (Mat-DB)

The web enabled Mat-DB is the result of merging the former Alloys-DB and Corrosion-DB. Mat-DB covers data on mechanical and thermophysical properties of engineering alloys at low, elevated and high temperatures for base materials and joints, and includes irradiation materials testing in the field of fusion and fission; tests on thermal barrier coating for gas turbines; and tests on mechanical properties of a corroded specimen. The corrosion part refers to weight gain or loss data on engineering alloys, ceramics and hot isostatic pressed powder materials exposed to high temperatures. The web enabled Mat-DB objectives and features include the following:

— Mechanical, thermophysical and corrosion properties data at low, elevated and high temperatures;
— Detailed meta-information on source, specimen, material, test condition and joining;
— Covers 34 test types (see Table 2);

TABLE 2. Mat-DB TEST TYPES

A. Mechanical properties
Crack growth and fracture
— Creep crack growth
— Cyclic creep crack growth
— Fatigue crack growth
— Fracture toughness
— Impact
Creep
— Cyclic
— Multi-axial
— Torsional
— Uni-axial
— Small punch
Relaxation
— Multi-axial
— Uni-axial
Fatigue
— High cycle
— Low cycle (load control)
— Low cycle (strain control)
— Thermal
— Thermomechanical
Irradiation
— Irradiation creep
— Swelling
Tensile
— Compression
— Multi-axial
— Uni-axial
— Small punch
B. Thermophysical properties
Density
Electrical resistivity
Emissivity
Linear thermal expansion
Poisson’s ratio
Specific heat
Shear modulus
Thermal conductivity
Thermal diffusivity
Young’s modulus
C. Corrosion
High temperature corrosion

— Designed for experimental data from standardized and pre-standardized tests;
— Over 40 000 public and restricted test results (including data received from the IAEA);
— Provides a web interface for data content, data entry, data retrieval and analysis routines (see Table 3);
— Allows XML related on-line data transfer from ‘test machine’ into Mat-DB;
— Unit conversion facility;
— Checks automatically on mandatory and standardized input in text fields;
— Commercially used as standalone PC and client/server application.

Figure 2 shows a screenshot of the Larson-Miller extrapolation programme with numerical and graphical results.

3.2. Document management system (DoMa)

The web enabled DoMa is designed to enhance the dissemination of information within the R&D community. Any type of electronic record

TABLE 3. Mat-DB ANALYSIS ROUTINES

A. Creep
Creep relations: Norton creep law, Prandtl creep law, Soderberg creep law, Monkman-Grant relation, Dobés-Milîcka relation
Extrapolation methods: Larson-Miller, Manson-Haferd, Manson-Brown, Orr-Sherby-Dorn, Spera, Minimum commitment method
Constitutive creep equations: Theta projection, Mc Vetty equation, Kachanov equation
Interpolation routines: Polynomial creep curve fit, Polynomial stress dependence, Isochronous & isostrain determination
B. Fatigue
Ludvik law, Manson-Coffin relation, Basquin analysis, Frequency modified Manson-Coffin relation
C. Crack growth
ASTM compliant creep crack growth analysis, creep crack growth plot, fatigue crack growth analysis
D. HT corrosion
Weight gain/loss analysis: Power law, Power law-time, Parabolic Δm^2, Parabolic $t_{1/2}$, $K_p(t)$, Breakaway

(i.e. document, spreadsheet, graphic, etc.) may be stored. The facility combines open access to general information (i.e. title, author, abstract, etc.) about a particular record with controlled access to the actual files. DoMa provides conservation, management and dissemination of documents, offers delegated administration of documents and access rights, and is used by energy related R&D projects for the management of internal documents and the dissemination of public reports. At JRC–Petten, DoMa has facilitated the use of networks for energy related R&D, specifically for nuclear energy and conventional energy.

The DoMa screenshot in Fig. 3 shows the folder structure on the left of the nuclear energy directory with a selection of the Fuel-DB within the high temperature reactor (HTR) fuel subdirectory. On the right, links to documents are shown with references to the authorization level.

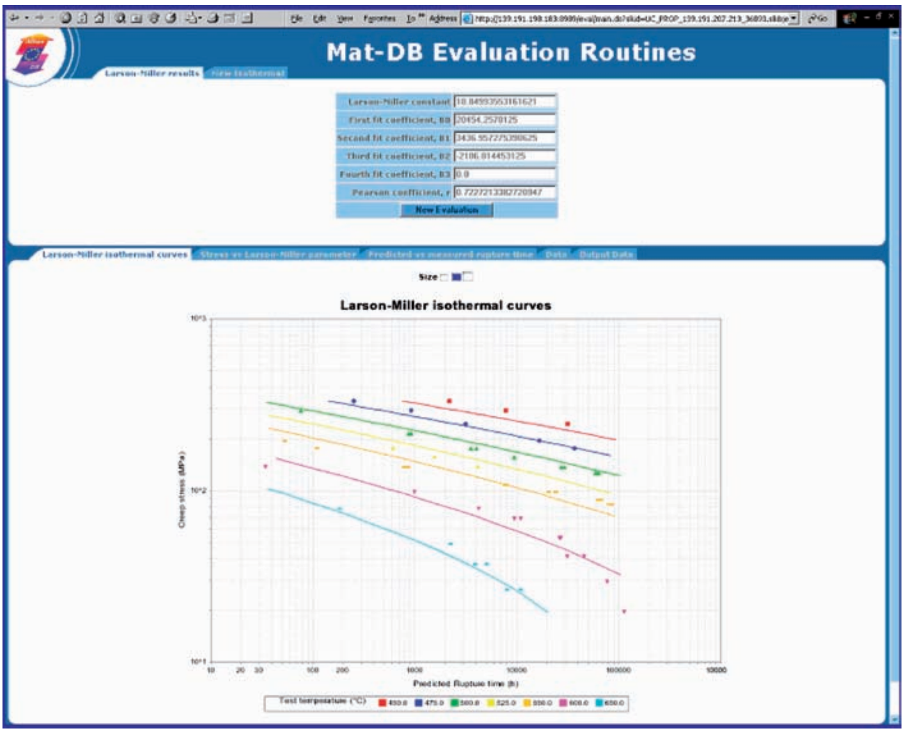

FIG. 2. Larson-Miller isothermals.

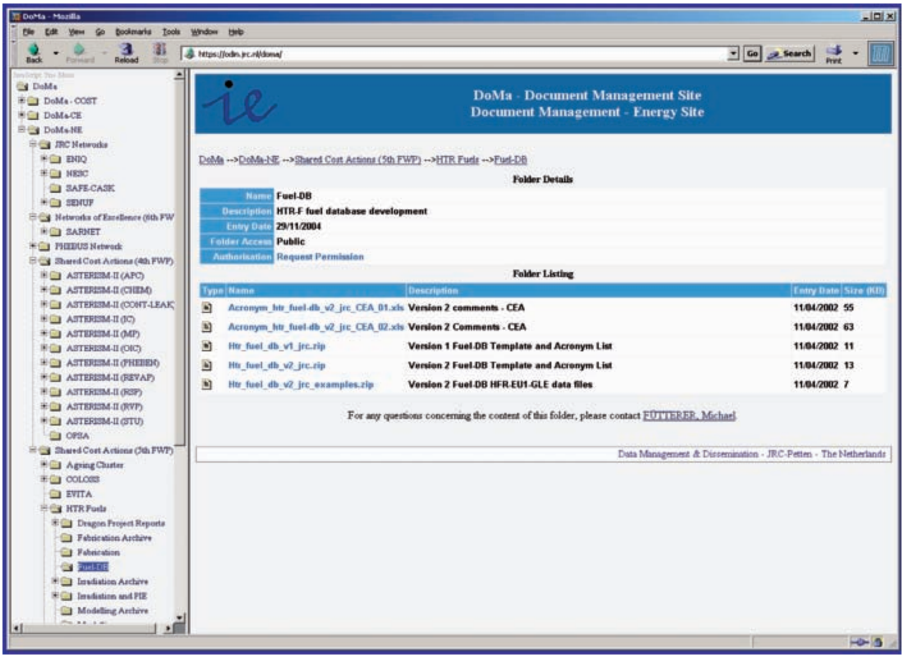

FIG. 3. DoMa screenshot.

3.3. Nuclear centres of competence database (NuCoC-DB)

The web enabled NuCoC-DB site provides access to the information gathered during a survey in the fields of fission and radiation protection and lists 218 European organizations. This study was initiated by the Committee for the EURATOM Research and Training Programme in the field of nuclear energy (1998–2002) with the intention to draw strategic conclusions regarding further needs in the field and reflects the present situation. It is an assessment of the relevant centres of competence in the fields of nuclear fission and radiation protection (NF & RP). The database allows a search on organization, department, NF & RP facility and activity. The NuCoC-DB screenshot in Fig. 4 shows a list of Nuclear Centres of Competence of all countries and all disciplines.

3.4. Safety of Eastern European type nuclear facilities database (SENUF-DB)

The web enabled SENUF-DB contains information on advanced and special equipment, tools, materials and processes in nuclear power plants. Maintenance and associated actions in nuclear power plants may require

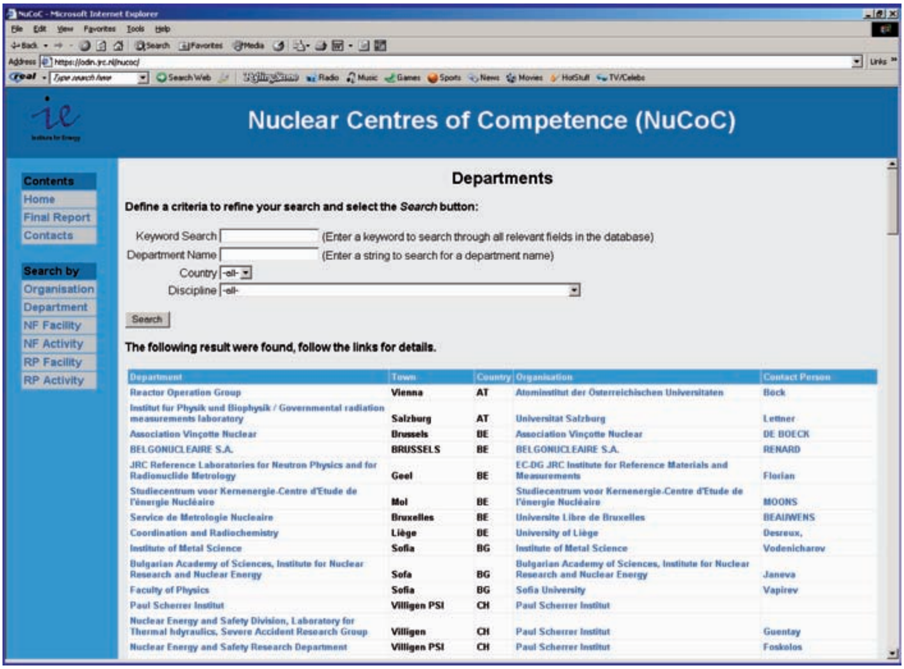

FIG. 4. NuCoC-DB screenshot.

individually tailored approaches and treatments to achieve both a proper technical solution and economic viability. Information about remotely controlled, specially designed and manufactured equipment, including their availability, main parameters and experience on their usage, are collected in the database. The aim is to provide maintenance managers and engineers with adequate information on the subject in order to help them select the most appropriate and cost efficient solution. SENUF-DB provides English and Russian user interfaces for data entry and retrieval. The screenshot in Fig. 5 shows the different data retrieval options.

3.5. Database on Research Reactors (DARES-DB)

The web enabled DARES-DB includes information on current research reactor safety assessment approaches as supplied by the operators. It aims at highlighting similarities and principal differences in the current best practices related to national requirements, periodic safety review (PSR) and probabil-

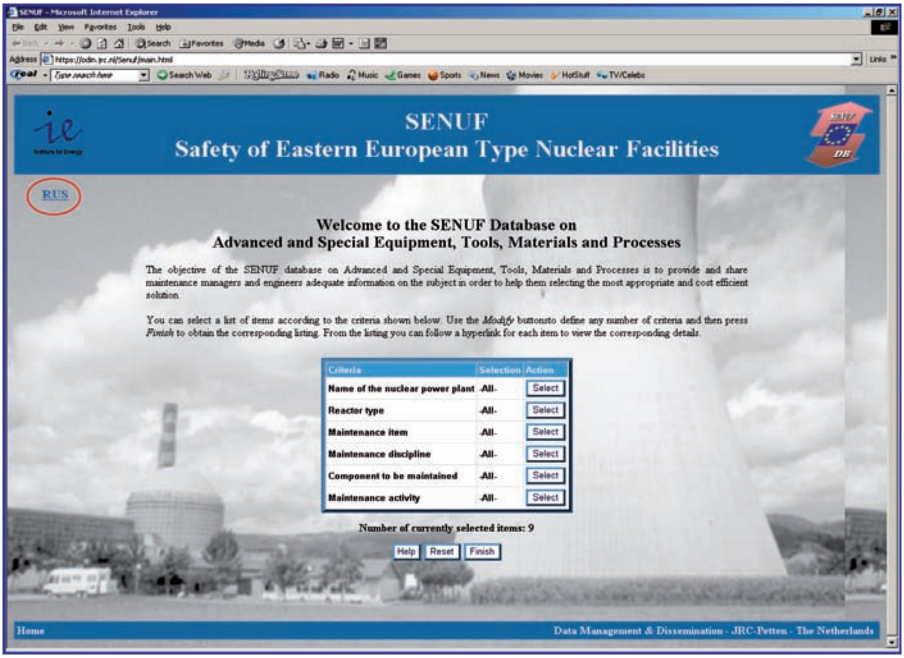

FIG. 5. SENUF-DB screenshot — English version.

istic safety assessment (PSA) for different types of research reactors in different countries.

The DARES-DB screenshot in Fig. 6 shows the three data retrieval options (country, reactor type and purpose).

3.6. Temperature Reactor Fuel Database (HTR Fuel-DB)

The HTR Fuel database (HTR Fuel-DB) has been developed as a prototype web enabled database application for experimentally measured HTR-fuel-element data and is restricted to project members. The HTR Fuel-DB has a complex structure with detailed meta-information about the data source, geometry of fuel elements, particles, coating layers, irradiation, etc. The data available at present are very limited. More data are expected from on-going irradiation experiments of various HTR-Fuel test programmes. Figure 7 shows the data retrieval options for source, type and label. The retrieved data are generated in reports with various links to detailed meta-information.

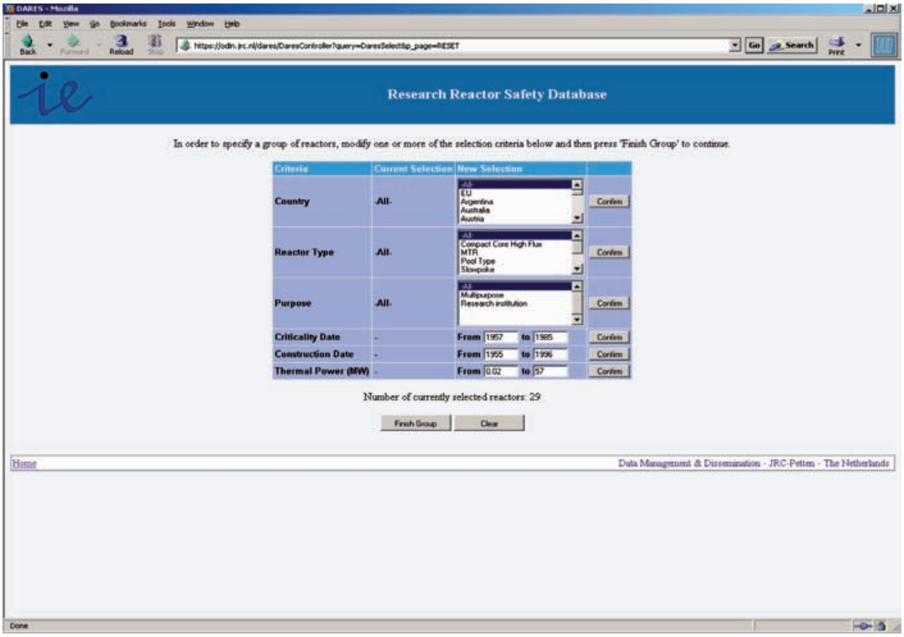

FIG. 6. DARES-DB screenshot.

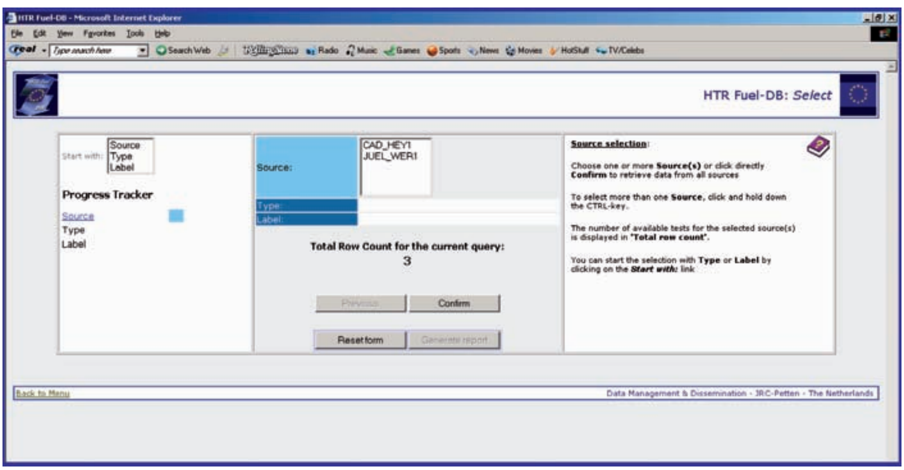

FIG. 7. HTR Fuel-DB data retrieval screenshot.

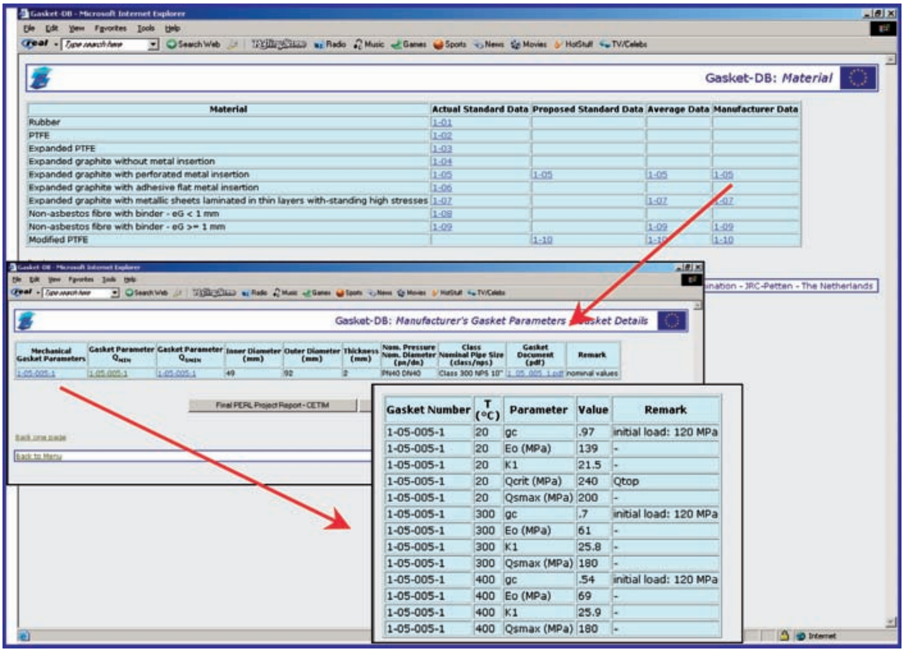

FIG. 8. Gasket-DB data retrieval screenshot.

3.7. Gasket-DB

The web enabled Gasket database (Gasket-DB) has been developed within the European PERL project (pressure equipment, reduction of leak rate — gasket parameter measurements). It contains gasket data from standard and experimentally measured manufacturers' data. The source of these data is only accessible for projects partners. The manufacturers' data are measured in German and French laboratories. The data sets contain much more detailed information than those published in the existing EN 1591-2 standard. One aim of the PERL project was the improvement of the standards. Figure 8 shows several Gasket-DB data retrieval steps and output information of test results for a commercially used gasket.

Any interested party can register in the ODIN portal https://odin.jrc.nl/ to have immediate access to those databases containing public data.

PRESERVATION AND MANAGEMENT OF KNOWLEDGE ON WWER REACTOR PRESSURE VESSELS

L. DEBARBERIS
JRC Institute for Energy of the European Commission,
Petten, Netherlands

M. BRUMOVSKY
Nuclear Research Institute Řež plc,
Řež, Czech Republic

Abstract

Preservation and management of knowledge are becoming a rising challenge and the importance of collecting all available information about the behaviour of different types of reactors, including WWER, is increasingly being recognized. Several experts are close to retirement, and preservation and use of their knowledge and experience will be nearly impossible in a few years. A new project is in progress at the Joint Research Centre of the European Commission (JRC-EC) Institute for Energy in cooperation with the Nuclear Research Institute Řež with the intention to collect all available information about reactor pressure vessels of WWER type reactors to analyse and summarize the most important items and issues. This project will contribute significantly to the new project Coordinated Action on VVER Safety (COVERS) on WWER Safety under the Framework Programme 6 of the European Commission (EC-FP6), in which all WWER operating countries are also taking part. The results of the project will be useful to young specialists of the new generation in all countries, since they would have access not only to current views and knowledge but also to the history and background on all aspects of WWER power plants. From the very beginning of researched studies and initial experiences with the operation of reactors, a large number of publications were issued in Russian as well as in other national languages (Czech, Slovak, Hungarian, Finnish, etc.). Today, there is no easy access to this substantial amount of information and experience for most foreign experts and WWER reactor operators in different countries. Many publications were also prepared in languages other than Russian for presentation at national conferences or workshops and appearing in national and international journals. Most of this information, experience and knowledge can not be retrieved easily. In the new project, more than 20 specialists, mainly from WWER operating countries, would help with the collection of such, mostly rare, publications. The first step focuses on obtaining full lists of publications dealing with material properties of WWER reactor pressure vessels (RPVs) and the results of studies, related to irradiation damage and testing of RPV steels, which are crucial for determining RPV life. The second step would focus on obtaining full texts of the relevant publications that can

not be found in standard libraries. This database of bibliographies (supported by full text of all included publications with abstracts in English and in electronic format) will be made available to all the contributing specialists. It is also intended to prepare a state of the art report on radiation damage in WWER reactor pressure vessels steels with the active participation of all contributing specialists. The structure and content of the report is proposed to be developed through a workshop in which these specialists would participate.

1. BACKGROUND

A generational gap is slowly appearing with regard to in-depth knowledge about the behaviour of reactor pressure vessels (RPV) materials and embrittlement issues, mainly due to the fact that the experts who took part in the design, construction and commissioning of the nuclear reactors have already retired or shifted to other jobs. The remaining experts are now approaching retirement. In addition, since the late 1980s there has been a significant fragmentation and dispersal of knowledge about the design of WWERs to many countries, including Hungary, Slovakia, Czech Republic, Bulgaria, Ukraine and the Russian Federation. Significant knowledge about WWER-440 is also available in Finland.

The new, internal JRC project SAFELIFE is dedicated to issues related to plant life management (PLIM) of ageing nuclear power plants [1–3]. Several networks, partnership projects and expert groups are operated by JRC on various PLIM disciplines. These include the major European networks: AMES, NESC, ENIQ, NET, SENUF and AMALIA (see Fig. 1). Developing networks is a key element of the JRC strategy [4] for the purpose of harmonization and best practice development among the Member States.

In particular, the European network AMES [5] is dedicated to the study of radiation embrittlement of RPVs, particularly WWER-RPVs, with the strongest connection to the present SAFELIFE initiative [6]. Within the frame of the SAFELIFE initiative of JRC Institute for Energy (JRC-IE), together with its key partner the Nuclear Research Institute (NRI), a new initiative in the area of knowledge management has been launched at the end of 2004.

2. SAFELIFE: A JOINT INITIATIVE OF JRC-IE AND NRI

The SAFELIFE initiative of JRC-IE in cooperation with NRI is currently concentrating on knowledge preservation as the first step of knowledge management. Collecting the scattered knowledge in various countries with

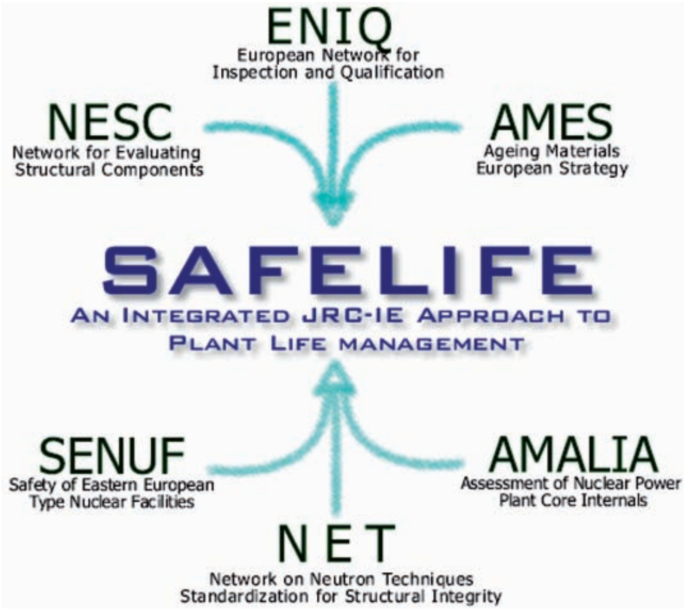

FIG. 1. Major European networks operated by JRC on PLIM.

WWER power plants and making it available to current and future owners, operators and regulators is considered an urgent task. A significant part of the existing information is in languages other than Russian and English. The approach followed in those cases is to provide a brief translation of the main conclusions and important facts in the collected documents. The SAFELIFE initiative is an example of practical deployment of effective knowledge management in the area of nuclear safety for the particular case of RPV embrittlement.

The project will contribute also directly to the Coordinated Action on VVER Safety (COVERS).

The general scope of the project can be summarized as follows:

— Collect all papers in their original language from countries having WWERs (Bulgaria, Czech Republic, Hungary, the Russian Federation, Slovakia and Ukraine); in particular, papers which never reached the international circuit;
— Prepare pdf files of original;
— Prepare a short English summary of the key data and conclusions;
— Organize a documentation database;

— Design and implement a system to manage such knowledge, including retrieval by keywords, tracing of authors, additional information, etc.

3. DEVELOPMENT STATUS AND PRELIMINARY RESULTS

A first call with a letter of intent (in English and Russian) has been issued at the beginning of 2005 to approximately 20 leading experts in different countries. The identification of experts was through direct knowledge among the members of the Ageing Materials European Strategy (AMES) network, the IGRMD community and IAEA experts. The country-wise distribution of the experts is given in Fig. 2. A series of workshops is planned with the experts.

The response to the call was unanimous and enthusiastic. A good number of papers and documents on the target subjects were collected in the first round. A large percentage of these are original and rare documents not found in the open literature. Figure 3 shows the distribution of papers and documents from each country into three categories: estimated total number of papers, number expected to be collected and the number already collected in the first round.

The collection of original documents and papers will be continued and additional incentives and measures will be used, including workshops. Figure 4 shows the subject-wise distribution of papers.

4. FOLLOW-UP

Figure 5 shows the methodology being used for the finalization of the first round of collection of papers from the predefined list with the assistance of identified experts.

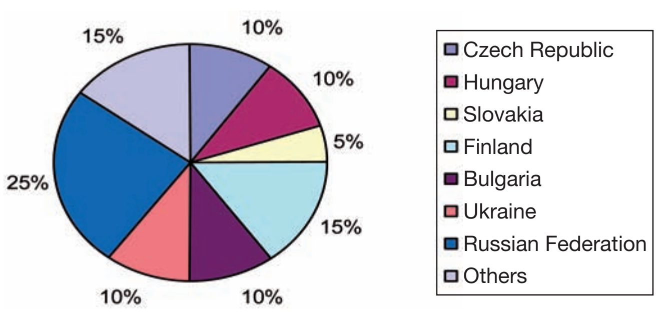

FIG. 2. Country-wise distribution of invited experts.

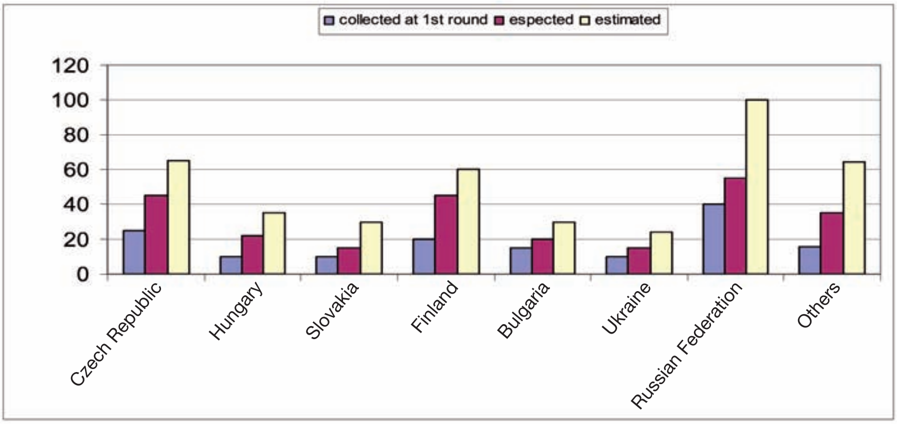

FIG. 3. Distribution of papers and documents.

The papers are screened and systematically filed in a dedicated documentation database. A series of workshops will support the analysis of the material and identification of the need for further rounds of collections. A few iterations should be sufficient to reach a reasonable inventory of information. The documentation database can then be stored and served as appropriate and can be reorganized to suit the requirement of the key projects, including SAFELIFE, COVERS and PERFECT.

5. CONCLUSIONS

The JRC-IE effort, in cooperation with the Nuclear Research Institute, Řež, towards knowledge preservation and knowledge management in the

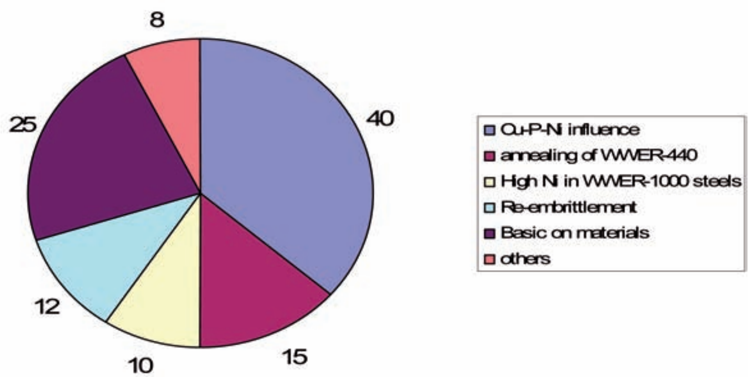

FIG. 4. Subject-wise distribution of papers.

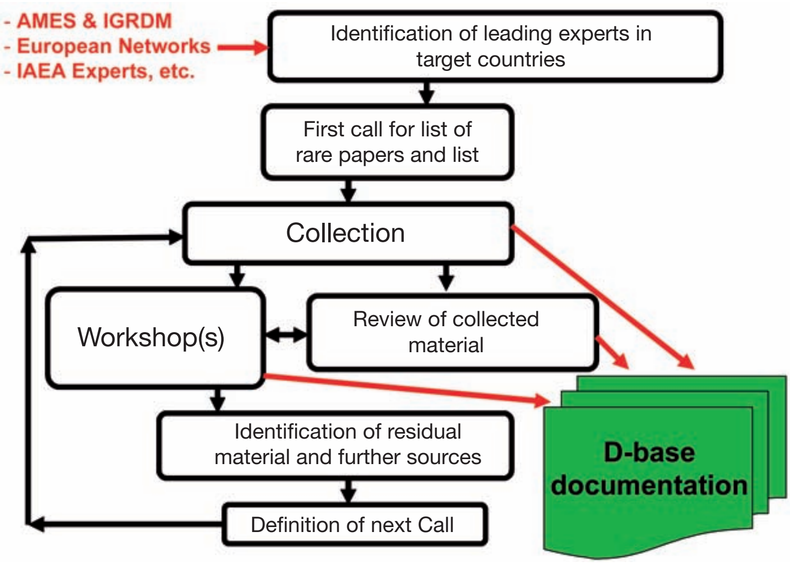

FIG. 5. Methodology.

specific field of RPV embrittlement is considered a very important task. The challenge is to collect all available information about the behaviour of WWER reactors using a systematic approach that would be suitable to the current phase of the plants' life.

A significant portion of the information is available with experts in the specialized field who have retired or are close to retirement. The preservation and use of their knowledge and experience will become more difficult or even impossible a few years from now and hence the task is urgent.

The SAFELIFE initiative will contribute significantly to the new EC-FP6 project COVERS on WWER Safety in which all WWER operating countries are participating. The results of the project will also be useful to young specialists of the new generation working on these plants in different countries, since they would have access not only to the current views and knowledge but also to WWER history and background.

ACKNOWLEDGEMENTS

The authors would like to thank the Data Management & Dissemination Sector of the JRC-IE for providing the IT tools to support the SAFELIFE initiative.

REFERENCES

[1] SAFELIFE web site, http://safelife.jrc.nl/

[2] SEVINI, F., DEBARBERIS, L., TAYLOR, GERARD, R., BRUMOVSKY, M., Study of Ageing Mechanisms for Structural Materials within SAFELIFE Project, Int. J. Strength Mater. **1** 367 (2004).

[3] DEBARBERIS, L., et al., "Recent advances in R&D to support understanding of RPV embrittlement within SAFELIFE action of EC-JRC-IE", Safety assurance of nuclear power plants with WWER (Proc. 4th Int. Conf. Moscow 2004) FSUE EDO Gidropress, Moscow (2004).

[4] DEBARBERIS, L., "Role of international networks on structuring nuclear safety research and disseminating results", FISA (Proc. Int. Conf.), European Commission, Luxemburg (2003).

[5] SEVINI, F., DEBARBERIS, L., GERARD, R., ENGLISH, C., "The AMES network towards the 6th Framework Programme", Material Science Problems in NPP Equipment Production and Operation (7th Int. Conf. St. Petersburg, 2002).

[6] KRYUKOV, A., DEBARBERIS, L., "Achievements, open issues and developments on VVER RPV irradiation embrittlement assessment and AMES European Network Strategy", paper presented at IAEA Specialist Mtg on Irradiation Embrittlement, Madrid (1999).

HUMAN RESOURCES AND KNOWLEDGE TRANSFER IN THE NUCLEAR SECTOR

(Session 3)

Chairperson

T. MAZOUR
IAEA

DISCUSSION OF ISSUES AND TERMINOLOGY FOR KNOWLEDGE TRANSFER

T. MAZOUR
Nuclear Power Engineering Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

The paper summarizes the results of a discussion led by the author at the beginning of Session 3 of the workshop, on issues and terminology related to knowledge management. A draft glossary of terms for knowledge management was introduced in Session 1 of the workshop. This discussion highlighted that many of the tools and methods for knowledge management that are most prominently publicized relate to capture and transfer of explicit knowledge in databases. However, the most difficult knowledge transfer challenges are in eliciting tacit knowledge which, unless it is suitable for conversion to explicit knowledge, needs to be transferred person to person through mentoring, redundancy, communities of practice, etc. Such methods require considerable resources and a culture that supports and encourages knowledge transfer.

1. INTRODUCTION

Some of the common terms in use related to knowledge management are explained below:

— *Knowledge:* While there are a variety of definitions for ‘knowledge’, one of the most common is “familiarity, awareness or understanding gained through experience or study”.
— *Explicit knowledge:* It refers to knowledge that is embedded in documents, drawings, calculations, designs, databases or procedures and manuals.
— *Tacit knowledge:* It is the knowledge that is held in a person’s mind and has typically not been captured or transferred in any formal way (if it were captured it would be explicit knowledge).

A clear distinction between explicit knowledge and tacit knowledge is the fact that explicit knowledge is easily duplicated and distributed while tacit knowledge is not.

One of the potential benefits of knowledge management is the elicitation of tacit knowledge and its conversion to explicit knowledge. This has been attempted in various settings for many years now with varying degrees of success. A general conclusion that can be drawn is that elicitation is difficult and results in incomplete (explicit) knowledge. It is difficult because people find it hard to be complete in describing what they know and it is incomplete because it always assumes background knowledge with the reader. The danger then is that the tacit knowledge converted to explicit knowledge might imply a level of comprehensiveness that it does not have. These difficulties have divided knowledge management experts into two camps.

The first camp views failures as largely technical. These experts are commonly technological *optimists* who believe that solutions will be found for the elicitation of knowledge as technology improves. They tend to focus on issues such as knowledge bases. In the second camp are the technological *sceptics*. They believe that elicitation of tacit knowledge is futile and that the endeavour should be abandoned altogether because it would never be possible to uncover and capture the rich common sense knowledge that underlies all of human reasoning. Hence, these researchers tend to focus on corporate culture and its effects on the *sharing* of knowledge.

2. KNOWLEDGE MANAGEMENT VERSUS INFORMATION MANAGEMENT

Another frequently used categorization of knowledge that is particularly popular with information scientists is based on three levels, namely, *data*, *information* and *knowledge*. 'Data' consist of raw text, numbers (such as 25°C), or even lines (such as lines in a drawing). This becomes 'information' when it is put in its meaningful context (the temperature outside is 25°C, a cross-section drawing of a pump). The information finally becomes 'knowledge' when it is applied in the human brain to interpret the world ("I don't need a coat because it is 25°C outside", "this pump will function correctly in the installation I'm designing").

There are some philosophical points against this categorization, most notably the fact that it is hard to distinguish when human interpretation sets in, thus it makes the distinctions fuzzy. Information scientists tend to view the categorization as linear (data lead to information, etc.) and see information as something external (see Fig. 1). A critique of this view is that such a meaning

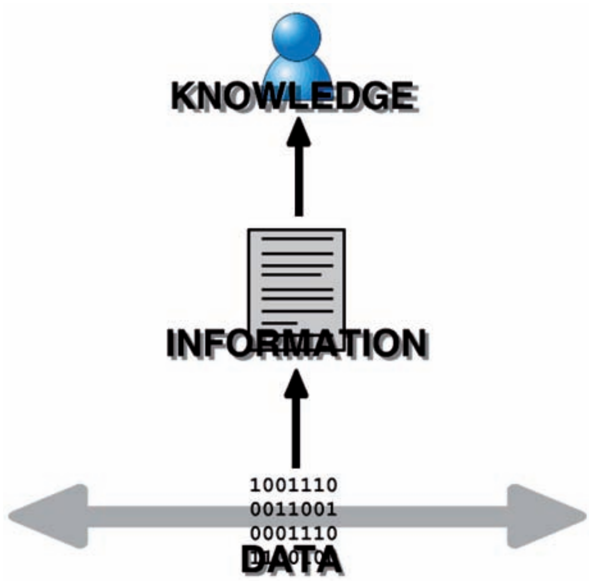

FIG. 1. Categorization of knowledge into three levels.

can only exist in people's minds and that it requires knowledge to attach meaning to data, thus making the categorization less linear.

Extracting tacit knowledge can be very difficult because such knowledge may be located in the expert's brain at what might be termed a subconscious level and is, by definition, not documented anywhere.

Within an organizational context, employees make use of knowledge that is not necessarily codified or even articulated. This knowledge is said to be tacit, yet comprises a viable source of information which can nevertheless largely be articulated. It is important to distinguish between tacit knowledge that is embodied in skills and can therefore be copied, and tacit knowledge that cannot be demonstrated and so is very difficult to transfer (e.g. the recognition of a musical note). We need to realize that a proportion of tacit knowledge can never actually be articulated, for "much of it cannot be elicited through introspection nor verbally articulated (relevant examples of the latter would include our tacit knowledge of grammatical or logical rules or even of most social conventions)".

3. TACIT KNOWLEDGE IN ORGANIZATIONS

Tacit knowledge in organizations is graphically depicted in Fig. 2.
The following is an example:

An experienced field operator walks into the turbine hall on his rounds, and recognizes that something is wrong. However, he can not explain why he suspects a fault. It could be an abnormal sound, smell, taste or a visual indication. Upon further investigation he finds that the turbine lube oil system is not operating properly. He diagnoses the source of the problem and corrects it, preventing a turbine trip or damage to the turbine.

It is interesting to note the ease with which the mother tongue is spoken — effortlessly and almost without error. If someone new to the language makes a mistake, it is often noticed and easily corrected. Yet, hardly anything explicit is known about its grammar, unless one remembers what was formally taught years after learning the language.

Similarly, the ability to recognize faces, even those that have not been seen for years, is amazing. When someone appears across the room, one knows right away that it is so-and-so. Yet, if one had to describe so-and-so for someone else to recognize, or make a sketch, it would probably be very

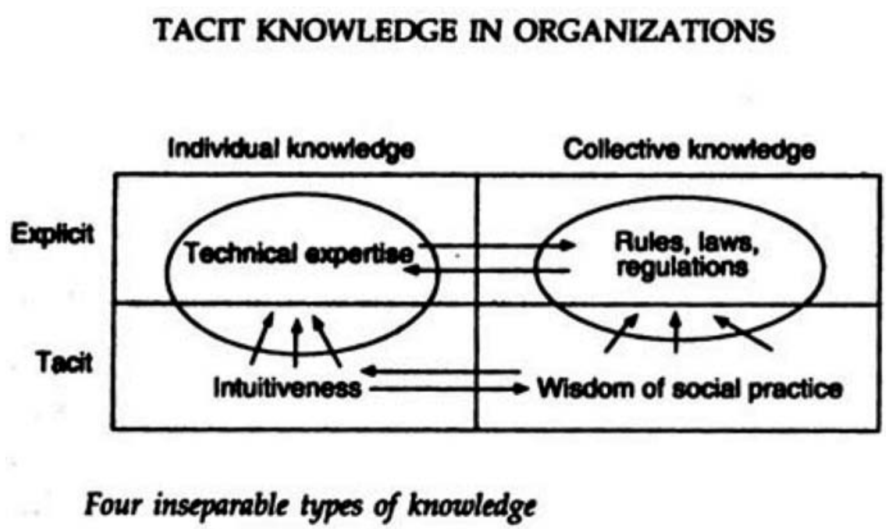

FIG. 2. Four types of organizational knowledge: explicit and tacit, individual and collective, from Baumard (1996).

difficult. One might know what so-and-so looks like, but not in the sense of knowing that allows expressing that knowledge for the benefit of others.

Up to 42% of the knowledge that professionals need to do their jobs comes from other people's brains — in the form of advice, opinions, judgements or answers (source: Delphi Group). So, it is somewhat surprising that so much of the focus in knowledge management, to date, has been on implementing processes and tools that support better management of explicit knowledge. This focus has come at the expense of tacit knowledge — knowledge which has not been documented or recorded and which exists in the heads of an organization's people.

4. IMMEDIATE AREAS OF INTEREST FOR A NUCLEAR POWER PLANT OPERATING ORGANIZATION

Immediate areas of interest for a nuclear power plant operating organization include the following:

- Transfer of knowledge from staff who were involved in the design, construction and commissioning of the plant to the next generation of nuclear power plant personnel (particularly tacit, undocumented knowledge);
- Collecting and maintaining information needed to maintain the 'safety case' required by the nuclear safety regulator (as well as other regulators);
- Maintaining effective configuration management controls (closely related to the previous point);
- Capturing and organizing information needed to effectively decommission units;
- Providing more effective ways to interact with suppliers, vendors and other outside organizations;
- Organizing plant information in such a way that facilitates its effective use on the job.

EXPERIENCE WITH KNOWLEDGE MANAGEMENT AT GRS — PART 2
Capturing expert knowledge and knowledge preservation

D. BERAHA
Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS),
Munich, Germany

Abstract

The incentives for implementation of knowledge management at GRS came from the growing concern about the loss of competence due to the retirement of many experts in the company. Since this problem is common to many of the German organizations in the nuclear field, a concept was developed which considered the application of knowledge management to a network of organizations. However, it was generally agreed that as a first step, GRS should implement its own knowledge management programme, which could help other organizations to assess the advantages and difficulties in the development of knowledge management tools and methods. In early 2001, the first efforts in developing a knowledge management programme at GRS focused on providing a sound basis for document management. Documents were traditionally stored in a large variety of different document repositories, such as databases and fileshares, as well as in paper document libraries. In addition, a platform had to be provided for exchanging information throughout the company. The solution adopted focused on an enterprise portal developed on the basis of MS Sharepoint Portal Server. In the next step, project activities were identified as the core business process which would gain from knowledge management techniques. A project server integrating project management software and project portals was set up and integrated with the portal. In parallel, methods and tools for capturing expert knowledge and knowledge preservation were studied and tested. In particular, knowledge representation and acquisition methods were tried out in prototype applications. These methods are ready to be deployed on a larger scale, taking advantage of the cooperation and document management features provided by the portal. The experience gained in knowledge management at GRS based on the lessons learned in the three years of activities and future development goals are presented in the paper.

1. BACKGROUND

Hiring at GRS was frozen for many years to achieve a planned reduction in personnel. However, in view of the loss of competence that would result from the retirement of 25% of the staff over a five year period, new staff is being hired again. Still, the loss of critical knowledge and the effective transfer of competence to a younger generation continue to remain the main concerns. There is no formal plan to date for the identification of critical knowledge. This is of concern since the long term plans need to be coordinated with the sponsors of GRS. At present, new staff members are being hired according to the most pressing needs. In the mid-term, implementation of a criticality assessment (following the example given by TVA) is envisaged. Training plays an important role in transferring knowledge; it will, however, not be the main topic in this paper. Suffice to say that outdated training modules have been restructured, training on the job is strongly advocated, and a mentoring system has been set up.

Besides training, methods for capturing the knowledge of leaving experts have been thoroughly investigated. The idea of eliciting the knowledge of individuals encountered some serious difficulties. The workload of experts tends to increase as retirement approaches, since the demands on them to fill existing gaps or to perform some pressing activities grow strongly as soon as notice of retirement spreads in the organization. Also, the financial basis for such activities after their retirement are not secured, as engagements after retirement are not encouraged. The efforts needed for such individual knowledge elicitation are commonly agreed to be very high, requiring not only a large portion of their time, but also putting high demands on the interviewers with respect to interviewing techniques and subsequent evaluation. It was concluded that individual knowledge elicitation is a very intensive process, in terms of time and cost.

In view of these difficulties, the strategic goals were respecified as follows:

— Capture and preserve knowledge of a knowledge domain in which the retiring expert is active, rather than concentrating on the individual's knowledge;
— Prevent knowledge capturing efforts in the future by strengthening the means to capture knowledge during the work processes of the expert;
— Improve the quality of information and document retrieval.

The first goal requires the development of methods of knowledge representation and knowledge modelling, whereas the second one concentrates on the processes (process oriented knowledge management).

2. KNOWLEDGE REPRESENTATION

Many ways exist to represent knowledge. At GRS, experience is available with dossiers, which is mainly a textual representation with embedded links to important resources. However, there is little flexibility with this type of representation with respect to collaboration on a topic by several authors. Furthermore, keeping the dossiers up to date is difficult. A new way of dealing with this type of documentation is shown by the success of the open net encyclopedia, the Wikipedia (http://www.wikipedia.org), which shows the way to a 'dynamic' collaboration on web documents. Another way of representation is the 'classical' web site, which tends to involve high maintenance efforts to keep the information up to date.

Knowledge representation as a scientific domain has gained strong momentum, particularly in view of the 'Semantic Net' proposed by Tim Berners-Lee (the 'father' of the Internet) as the next 'intelligent' Internet. Without going into details, the methods are mainly based on a conceptualization of a given knowledge domain, collection of relevant facts and objects ('concepts' or 'classes') in the domain, the characterization of the concepts by its properties ('attributes'), descriptions of the relations between concepts ('relations'), and the assignment of individuals ('instances') to concepts. Several methods, such as 'topic maps', 'concept maps' or 'ontologies' are available, differing in the degree of formalization. In general, they offer a systematic approach to knowledge representation and a controlled vocabulary set up by experts to describe the domain, as well as visualization and search facilities to navigate the maps. In more formal cases, such as ontologies, the domain may be 'understood' by machines to draw inferences, checking consistency, etc.

Some powerful tools have been tried out in prototype applications. One of the tools is the CmapTools set for constructing concepts maps developed by the Institute for Human and Machine Cognition (IHMC), which is extremely easy to learn and use. The prototype applications are related to the knowledge domain of Component Safety and representing the knowledge management activities at GRS in the form of a concept map. A second tool, the Semantic Miner by Ontoprise, has provided the basis for a pilot project aimed at mapping the GRS knowledge in the domain of Containment. To develop the containment ontology, a two day workshop has been held with four experts in the field and three knowledge workers. In this workshop, a skeleton ontology has been developed, which was subsequently refined by including relations and resources. The controlled vocabulary (the ontology's concepts) is used for searching either the GRS document management system, or the Internet. By using search terms, which have been agreed to be the right ones by field experts, search is distinctly improved.

3. STRATEGIC GOAL OF KNOWLEDGE MANAGEMENT AT GRS

As mentioned, a strategic goal of knowledge management is to avoid the future need for capturing the knowledge of retiring experts. In order to achieve this goal, process oriented knowledge management is being implemented. The main idea of process oriented methods is to capture knowledge as it is being produced in the work process, and to make it available when needed. The methods are mainly based on process models, which in many cases are already set up in the form of workflows. The workflows are then analysed from the point of information and knowledge flows. For each step in the workflows, the information and knowledge input is gathered. The knowledge related output of the step is then examined with respect to the repositories where it should be stored, the people to whom the information must be transmitted, and so on.

At GRS, the most important business process is the project. Hence, process oriented knowledge management must first consider projects. As projects in general do not exhibit rigid structures and vary in their size from very small to large projects, a simple template was developed, which could be adapted to the specific needs of each project. The template contains a starting point, milestones and an end point. At the start of the project, a state of the art report should summarize the technical or scientific initial point. At milestones or at the end of the project, a debriefing session should be held with the participation of the project controller, the project leader and his or her team. The main aim of the debriefing session is to structure the project portal, to map the project knowledge (only for large projects), and to fill out a ‘lessons learned’ form. For complex projects, a more elaborate structure may be set up on the basis of the workflow and include several project stages.

4. SUMMARY AND CONCLUSIONS

The experience gained to date shows that in capturing the knowledge of experts who are leaving the project or organization, the identification of critical knowledge is still missing. Also, the capturing process is only an informal one and would need firm guidelines. However, strategies are in place which try to enlarge the scope of knowledge elicitation to that of knowledge representation and modelling.

Concepts of knowledge representation have reached a stage where the tools are in place and the notion of knowledge representation and modelling, as well as the interest in it, is spreading after a demonstration of pilot applications. In particular, it has been shown that these methods may appreciably improve navigation and retrieval of information.

Process oriented knowledge management has brought initial rewards. The project portal provides a place for every project, where all information and documentation relevant to the project is concentrated. This enables a quick and comprehensive view of the progress of the current project and the accomplishments of previous projects. In addition, methods related to process oriented knowledge management enhance project information by state of the art reports and lessons learned. The utilization of these new tools is still at an early stage, but quickly gaining momentum.

CAPTURING TACIT KNOWLEDGE

R. WORKMAN
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

The paper outlines an exercise in which workshop participants were asked to address certain questions in relation to the capturing of tacit knowledge. The questions are included, along with the output generated from the sessions. A brief description of a case study is included.

1. INTRODUCTION

Capturing tacit knowledge is one of the most important elements of the preservation of nuclear knowledge. It is the accumulated knowledge held by those researchers, scientists, technologists, engineers, plant managers and operators who are working, or have worked, within the industry itself that is of critical importance.

Various attempts have been made to capture such knowledge. It is a subject that knowledge management practitioners and those who operate on the periphery like to discuss. Some people feel that it is difficult to achieve an effective outcome. There are, however, methodologies in place that have been used for tacit to tacit knowledge transfer or for tacit to explicit transfer. Both outputs are equally valid. The benefit of the latter approach is that there remains a tangible outcome from the process. This output can be used by those currently working in the industry, but is likely to be of particular benefit to the new generation of graduates who take up positions within the industry. It is not just in the short term that such knowledge will prove valuable, as it will be available for those generations who will eventually manage the decommissioning of nuclear facilities.

The workshop on Managing Nuclear Knowledge, held at the ICTP in Trieste in August 2005, brought together experienced practitioners in nuclear knowledge management. This created a unique opportunity to elicit their views on the question of capturing tacit knowledge.

2. CASE STUDY

A case study was presented, which summarized a successful programme of work that had been carried out within the research and technology function of British Nuclear Fuels plc between 2001 and 2004. The work had technology as its focus. A decision was made at the outset that knowledge associated with certain key technologies was the top priority. The programme was later extended to embrace a range of technologies of importance to the company, as it was realized that the process was starting to move naturally into other subject areas. The pursuit of a 'knowledge thread' led to the discovery of connections that enabled a 'knowledge map' to be developed. The knowledge thread itself indicated that any attempt to capture knowledge on one technology, in isolation from related technologies, might prove to be counterproductive. The results of this programme of work have been described elsewhere.*

3. THE WORKSHOP EXERCISE

The following four strategic areas were outlined:

— Knowledge capture;
— Knowledge transfer;
— Knowledge gaps;
— Knowledge targets.

The workshop participants were divided into four syndicate groups. They were allowed to select the aspect that they wished to work on. They were asked to discuss the four questions posed for their chosen area. The process was facilitated and the results were reported back to all participants.

3.1. Questions addressed

Knowledge capture:

— Why capture tacit knowledge?
— From whom might you wish to capture it?

* WORKMAN, R., "Preservation and reuse of nuclear knowledge in the UK nuclear industry", Managing Nuclear Knowledge: Strategies and Human Resource Development (Proc. Conf. Saclay, 2004), IAEA, Vienna (2006).

— What kind of knowledge might you wish to capture?
— How might it be captured?

Knowledge transfer:

— What might you do with the knowledge once captured?
— How might it be transferred?
— What are the ways in which it could be utilized in the future?
— What might be the benefits?

Knowledge gaps:

— Are there large age gaps within your organization?
— Is your organization losing experienced people?
— Does your organization have a graduate recruitment programme?
— Do you still have access to retired staff?

Knowledge targets:

— Is there a need within your organization to preserve knowledge for future reuse?
— Which areas of nuclear knowledge would you target?
— What is important for your organization:
  - Now?
  - In the future?
— Are there projects in which you feel sufficient knowledge has not been captured?

3.2. Output generated

The results of the exercise are summarized for each of the working groups.

Working Group 1: Knowledge capture

The need to capture tacit knowledge is important for the effective and efficient work of the organization and to ensure that the knowledge and experience of senior staff are not lost due to retirement.

Tacit knowledge of every worker has to be captured, especially those with several years of experience and close to retirement. However, it is important to capture knowledge as it is produced rather than waiting to capture it prior to the retirement of experts.

The kind of knowledge that should be captured could be prioritized on the basis of a risk assessment due to loss of items of knowledge. It is also important to capture the attitude of workers with good performance and ensure its transfer to the entire workforce.

Availability of appropriate tools to capture knowledge is very important. Currently each organization is trying to evolve its own methodology and tools. Examples include maintaining an expert pool of retired staff to be available on request; awarding part-time contracts on specific tasks to retirees; associating new workers with expert staff in joint work programmes; video recording of work to capture processes and skills; preparing documents on specific topics; and using experienced people to develop training material for abnormal operations. Developing guidance on knowledge preservation and capture strategies, tools and techniques, is an urgent need.

Working Group 2: Knowledge transfer

Regarding what needs to be done with captured knowledge, the opinion of the working group was that a strategy should first be developed on its preservation and use. The elements of such a strategy could be to validate the captured knowledge as correct and relevant; embed knowledge and information into processes wherever possible; and avoid past mistakes in building expert systems.

Measures for transferring knowledge include post-job debriefs implemented on a peer to peer basis rather than a lecture by the boss; and storytelling, which is particularly suited to transferring operating experience.

It is important to note that not all tacit knowledge can be made explicit. Dissemination of knowledge to universities and students, and working with them closely would encourage young people to consider working in the nuclear industry. The Canadian experience (UNENE) of annual meetings between university and industry to exchange information and knowledge is considered a good practice in this regard. The need for different methods in dealing with research institutes and universities should be recognized.

The benefits of knowledge transfer would be both in the short term and long term and would result in improving the decision making process. Reuse of knowledge would result in economic benefits and also avoid repetition of past mistakes.

Working Group 3: Knowledge gaps

Members of the working group stated that they do not have large age gaps in their organizations but these could manifest in future due to restructuring, introduction of new technology, modernization and eventually decommissioning. There are gaps, however, in knowledge about research reactors. It would be necessary to carry out an assessment of knowledge gaps.

Most of the organizations in Eastern European countries are losing people due to salary issues and ‘brain drain’. The next five to ten years would be a critical period with respect to the loss of experienced staff and in some cases losses of up to 50% are expected. It is, therefore, very important to develop appropriate strategies for human resource management, including graduate recruitment programmes.

Members of the working group mentioned that they have only partial access to retired staff in their organizations. In some cases, award of contracts to retirees was not possible and retirees could not be recruited to certain positions in the organization. Appropriate mechanisms and incentives need to be developed to facilitate utilization of retired staff.

Working Group 4: Knowledge targets

The areas of nuclear knowledge targets identified include knowledge about all aspects of nuclear reactors; decommissioning of nuclear reactors and nuclear facilities; and development of nuclear technologies.

The working group concluded that developing an appropriate organizational culture would be the most important goal for their organizations. The organizational culture should facilitate overcoming current problems, such as a lack of suitable succession planning for technology development and operations; a wide variation among different levels of management on the most important concerns to be addressed; and the unavailability of more than one expert in some important areas.

There are certain factors specific to the nuclear industry which result in a unique set of problems. For example, the petroleum industry has a more rapid turnover of staff, so documentation is built into the process and manuals are improved from the lessons learned. Adoption of an appropriate strategy from the inception of NPP projects is expected to remove the subsequent need for specific knowledge capture projects.

The group discussed the issue of whether or not to worry about how to capture know-how. The new generation may be innovative in ways of fixing problems, which may remove the need for capturing know-how from the critical list of priorities.

KNOWLEDGE MANAGEMENT INITIATIVES AT THE MALAYSIAN INSTITUTE FOR NUCLEAR TECHNOLOGY RESEARCH

A. RAPIEH
Malaysian Institute for Nuclear Technology Research,
Bangi, Kajang,
Selangor, Malaysia

Abstract

Knowledge management is basically managing the knowledge culture and the knowledge management system. In this early stage of knowledge management in the Malaysian Institute for Nuclear Technology Research (MINT), emphasis is given to the cultural and human aspects of knowledge management, which are more challenging and time consuming but more effective in the long run. Being a knowledge based organization, whose core activity is research and development in nuclear and related fields, MINT would like to strengthen its knowledge management with the objectives of intensifying innovation, achieving high customer and stakeholder satisfaction, developing innovative knowledge professionals and instituting a strong knowledge management culture. In the initial stages, we do this by nurturing the following eight basic knowledge management habits in individuals in the organization: identification, acquisition, application, sharing, development, creation, preservation and measurement of knowledge. With regard to systems, we give priority to those that support the maintenance and sharing of information and knowledge, particularly on competencies and expertise of our professional and technical staff, lessons learned and frequently used information. Policy and organization structures to support knowledge management have been formalized. Some knowledge management systems have been developed and others are in the process of development.

1. INTRODUCTION

The Malaysian Institute for Nuclear Technology Research (MINT) has a workforce of around 800, of which 330 are scientists or engineers. The country's population is about 23 million. We have no nuclear power plant and have no plans yet to have one. However, in recent months we have received indications of interest in nuclear power among policy makers and businesspeople due to the recent increase in oil price.

Knowledge management was formally introduced in MINT in 2002, when a knowledge management workshop was held for senior and middle level management. Since then, several knowledge management enthusiasts went for training and implemented knowledge management at their workplace. In 2004, the management of human resource development (HRD) was reorganized in line with knowledge management principles and HRD information, and a competency management system was developed. It was only in 2005 that a knowledge management strategic plan was formulated and implemented.

2. RATIONALE FOR KNOWLEDGE MANAGEMENT

MINT is a knowledge based R&D organization and as such we need to increase the intensity of innovation to gain competitive advantage. For this purpose we need to identify, acquire, share, apply, develop, create and preserve knowledge. It is our hope that these behaviours become the habit of every individual in MINT and not just practiced sometimes by some individuals.

We are also facing the problem of an ageing workforce. Part of the problem was mitigated when we recruited around 160 new researchers between 2000 and 2002 to replace about 100 researchers who will be retiring within ten years and 60 researchers who will be retiring in the years ahead. The other problem is to retain, preserve and transfer their knowledge, and these aspects have to be addressed through well planned knowledge management initiatives.

3. KNOWLEDGE MANAGEMENT DEFINITION AND APPROACH

Knowledge management is the management of organizational knowledge for creating business value and generating a competitive advantage or the ability to create and retain greater value from core business competencies. It enables the creation, communication and application of knowledge of all kinds to achieve business goals [1]. Knowledge management is expected to help us address the issues mentioned above and other organizational problems related to delivering innovative products and services, managing and enhancing relationships, and improving work processes and practices.

Our approach to knowledge management in MINT is to inculcate the knowledge management culture first and then develop and manage the knowledge management system. A knowledge friendly culture is one of the most important conditions leading to the success of a knowledge management project but perhaps the hardest to build from scratch [2]. ‘Culture’ is formed when every individual in the group practices the same habits or behaviours and values. In this context, ‘culture’ applies to a group, organization or community, whereas ‘habit’ applies to individuals. In order to form a knowledge management culture, it is necessary for every individual in the organization to know the importance of knowledge management habits, learn to practise consciously and finally follow them subconsciously when they become habits. When every individual in the organization has acquired all the knowledge management habits, then a knowledge management culture would manifest very strongly [3].

There are eight key habits of knowledge management [3]:

(1) Knowledge identification;
(2) Knowledge acquisition;
(3) Knowledge application;
(4) Knowledge sharing;
(5) Knowledge development;
(6) Knowledge creation;
(7) Knowledge preservation;
(8) Knowledge measurement.

The following six enablers are required to cultivate the eight knowledge management habits [3]:

(1) *Physical architecture:* Space or room with appropriate furniture, facility and design to provide an environment that is conducive to endorsing and implementing knowledge management initiatives and providing constant reinforcement.
(2) *Structural design:* Both formal (flatter organization structure) and informal (objective driven and self-organizing) network of knowledgeable specialists that can face the challenge of the 'knowledge economy'.
(3) *Living 'knowledge policy' and 'knowledge plan'* — to guide the implementation of knowledge management initiatives.
(4) *'Knowledge tools':* Instrument, template, platform or system to practise or implement knowledge management, e.g. lessons learned, FAQ, Yellow Pages, knowledge based performance management, etc.
(5) *Human capital:* 'Knowledge professionals' with distinctive competencies and innovative leaders facilitating them to contribute.
(6) *Technology ICT* — to facilitate the implementation of knowledge management.

4. KNOWLEDGE MANAGEMENT INITIATIVES IN MINT

4.1. The first initiative

The first initiative was to formulate, adopt and implement knowledge management policy, objectives, strategies, activities and structure.

4.1.1. MINT knowledge management policy

As a knowledge based organization, MINT shall strengthen its knowledge management by inculcating and nurturing knowledge management habits, particularly knowledge identification, knowledge acquisition, knowledge sharing and knowledge preservation at the initial stage, establishing mechanisms, procedures and systems to gather, organize and share explicit and tacit knowledge (publications, experience, etc.) of researchers and technical support staff, lessons learned and frequently used information so that it could be shared, utilized and further developed.

4.1.2. MINT knowledge management objectives

MINT knowledge objectives are as follows:

(a) Inculcate knowledge management culture;
(b) Develop innovative ‘knowledge workers’;
(c) Intensify innovation;
(d) Increase customer and stakeholder satisfaction;
(e) Improve organizational excellence.

4.1.3. MINT knowledge management strategies

MINT knowledge management strategies are as follows:

(1) Inculcate knowledge management habits through specific programmes and activities and by providing the system, procedures, time and place to practise the habits.
(2) Transform MINT staff into ‘knowledge workers’, knowledgeable, innovative, satisfying customers and stakeholders, and practising teamwork.
(3) Capture information and knowledge at the point it is produced, document, organize and preserve.
(4) Encourage utilization and sharing of knowledge.

(5) Promote lifelong learning.
(6) Develop systems, procedures and technology to capture, share and utilize lessons learned and develop best practices.
(7) Organize programmes and develop systems for sharing and transferring knowledge on core competencies among organizational members.
(8) Promote the formation of a 'community of practice' to provide a forum for sharing and transferring of knowledge, intellectual discussion, collaboration, cooperation and networking.
(9) Develop infrastructure and 'infostructure' to support knowledge management initiatives.

4.1.4. Knowledge management organization structure

In the formal knowledge management structure at the higher or policy level, we have the Steering Committee chaired by the Director General and comprising the top management up to Divisional Directors. At the operational level we have the Implementation Committee chaired by the Deputy Director General of Corporate Program, comprising representatives of each division.

4.2. Integrated management system (IMS)

The IMS, based on the IAEA Safety Requirements (see Ref. [4]) and the Safety Guide (see Ref. [5]), will be initiated next year. This system will integrate all the quality systems, such as ISO-9001, ISO-17025, ISO-18000 and ISO-14000, that are being practised currently. A portal is being established to support this and all other information and communication needs.

4.3. Managing and preserving nuclear knowledge

This is a monumental and very challenging task and we are taking it a step at a time. A lot more needs to be done. Some examples of activities for knowledge preservation are discussed in the following subsections.

4.4. Lessons learned

The following list describes the lessons learned:

(1) This is a system to capture lessons learned both from success stories and mistakes. The system is linked to manuals and procedures which are being revised from time to time based on the lessons learned.
(2) Frequently used information is stored on the local web.

(3) Learning sessions are recorded. Training rooms are equipped with video recording systems.
(4) Curriculum and manual for R&D management: a group made up of research managers with many years of experience has been formed to write the manual or book to be used as a reference for systematic training in R&D management. By writing the book the experience of the writers in managing R&D is preserved.

4.5. Human resources

HRD is always given emphasis and a division is tasked to handle this. A guideline for managing HRD has been issued outlining the principles and procedures, and a web based system is under development to enable staff to self-manage their development based on the guidelines. Apart from the usual training courses and seminars held in-house and outside the organization, some other initiatives are outlined below:

(1) Competency Management System enables training needs analysis, competency assessment, competency measurement and compilation of an inventory of competencies.
(2) Postgraduate studies on the job. Our researchers can use their research project as theses for Master's or PhD degrees. In this way, everyone has a chance to get higher degrees and does not have to leave their laboratory for that purpose.
(3) More than 200 students from universities and colleges come to MINT for training every year.
(4) We also monitor university curricula from time to time and make recommendations for appropriate actions.

4.6. Networking for education, training and knowledge transfer

A lot of networking takes place with universities through 'on the job' postgraduate programmes. Apart from this, the following are some examples of other networking initiatives for education, training and knowledge transfer:

(1) University lecturers, researchers from research organizations and MINT researchers from research interest groups or 'community of practice' on various research topics and colloquia are held from time to time.
(2) We also benefit from being a member of ANENT, ANSN, FNCA and other organizations.

(3) We have a memorandum of understanding/memorandum of agreement (MOU/MOA) with several organizations locally and overseas. Joint projects under these MOU/MOA provide opportunities for knowledge sharing and transfer.

5. CHALLENGES

There are several challenges in inculcating the knowledge management culture and in maintaining the knowledge management system with the existing staffing levels. Technology helps but it requires high investment, skill, effort and time. Leadership commitment and support has to be very strong and visible to people in the organization in order to motivate them to bear the extra workload as a result of knowledge management. We also need to grow and sustain many knowledge management champions to spread the idea and benefits of knowledge management, and sustain the knowledge management activities. Inculcation of culture takes a lot of time, effort and creativity, and the perseverance of knowledge management champions in the organization is highly desired.

6. CONCLUSION

This is a brief overview of knowledge management in MINT and does not cover all knowledge management activities that are happening. After all, knowledge management is not something that is totally new, and many activities and processes resembling knowledge management were in place before knowledge management was formally introduced. With the knowledge management policy, knowledge management is formalized in MINT. The policy will be a living and dynamic one and will be reviewed from time to depending on our progress and priorities.

REFERENCES

[1] TIWANA, A., The Knowledge Management Toolkit, Prentice Hall, Upper Saddle River, NJ (2000).
[2] DAVENPORT, PRUSAK, Working Knowledge, Harvard Business School Press, Boston, MA (1998).
[3] OW, F., Lecture notes, JT Frank Management Centre, Kuala Lumpur.

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, The Management System for Facilities and Activities Safety Requirements, IAEA Safety Standards Series No. GS-R-3, IAEA, Vienna (2006).
[5] INTERNATIONAL ATOMIC ENERGY AGENCY, Application of the Management System for Facilities and Activities Safety Guide, IAEA Safety Standards Series No. GS-G-3.1, IAEA, Vienna (2006).

DATABASE APPROACHES TO SAFETY CASE INFORMATION CAPTURE, INTERROGATION AND MAINTENANCE

C.K. BRIGHT
British Nuclear Group,
Management Services Sellafield Ltd,
Cheshire, United Kingdom

Abstract

There is a wide range of knowledge management techniques and tools. Several of these techniques rely on post hoc capture or acquisition of knowledge, for example, techniques such as oral histories and exit interviews. Undoubtedly important techniques, their full value can, however, be undermined by a number of factors. For example, they are not always systematically applied; the knowledge acquired is unstructured; and the reuse of the acquired knowledge is often dependent upon a detailed understanding of the context in which it was previously gleaned or applied. The paper looks at an alternative, potentially complementary approach for knowledge capture whereby knowledge is captured in situ. The paper describes by means of a case study, a structured approach to capturing knowledge in the context of the development and use of radiological plant safety cases — more specifically, the scope of information related to the identification of safety systems and equipment, and the role of those systems and equipment in identified fault scenarios. The database application served a number of purposes. It facilitated the capture, formatting and output of the requisite as part of the safety case documentation. The resultant database enabled a more flexible means to share information during the formulation of the safety case (by plant operators, safety assessors and engineers) and also provided a potential for plant operators or other safety case authors to interrogate access to the safety case information. In this way the tools could, for example, be interrogated to identify what the key safety systems on the plant are, and what the typical fault scenarios identified on a plant of this type are. As the information was captured in a structured format they provided a subsequent repository of knowledge that could be interrogated either within a single plant safety case or across a number of related safety cases.

1. BACKGROUND

"Knowledge management can be defined as the identification, optimization and active management of intellectual assets, either in the form of

> explicit knowledge held in artifacts or as tacit knowledge possessed by individuals or communities." [1]

On the surface of it, the role and relevance of knowledge management within the nuclear industry, and more specifically within British Nuclear Group may seem unclear. Indeed, as is often the case with business management initiatives, the topic of knowledge management has had criticism levelled at it that it is just a management 'fad', or an academic field of study with little applicable value.

There are, however, many aspects of the nuclear industry that warrant closer inspection. There is a growing awareness of the importance of a focus on knowledge management issues, evidenced by the work of the IAEA, for example, and the importance being ascribed to knowledge management through that organization:

> "Over a very short period, the IAEA has underscored the importance of the Nuclear Knowledge Management issue…Within its activities; the Agency has elevated nuclear knowledge management with Member States to a central position…" [2]

Much of the interest in the nuclear industry revolves around the problems associated with an ageing workforce and the significantly reduced influx of a new generation of nuclear engineers and scientists [3]. While the headline issue relates to an ageing workforce there are, however, a wide range of issues facing the industry.

2. TRENDS IN THE FIELD OF KNOWLEDGE MANAGEMENT

Development of the knowledge management field has undergone a number of changes and emphases. One approach distinguishes between first and second generation knowledge management (see Ref. [4]). Early knowledge management focused heavily upon the capture and dissemination of skills and experience so that it could be used by an organization. The use of information technology (e.g. involving databases and intranet technology) was central in providing a means by which to store and disseminate knowledge. Second generation knowledge management has focused less on knowledge capture and more upon how knowledge is created and shared. The prevalence in the setting up of 'communities of practice' is a clear demonstration of this shift in emphasis. Communities of practice involve the sharing of knowledge through formal or informal 'interest groups' or 'working parties' within an organization.

3. KNOWLEDGE MANAGEMENT APPROACHES AND METHODS

As implied by the previous section, a range of knowledge management approaches and methods exists. This range forms 'knowledge elicitation' techniques drawn from the area of artificial intelligence and knowledge based systems, such as structured interviewing, observation and knowledge modelling through to mentoring and 'apprenticeships' drawing from training and human resource management.

To a large extent, given this breadth of approaches and methods, knowledge management can be thought of as comprising a range of methods and approaches aimed at managing an organization's intellectual assets. In this view, knowledge management should not be seen as an 'initiative' in itself, rather a battery of techniques that can be brought to bear in given situations.

At the same time, much of the emphasis in knowledge management has tended to focus on eliciting or capturing knowledge after it has been 'compiled'. Prime examples of this is the use of 'exit interviews' or post-project reviews to gather knowledge and experience at the point an employee is about to leave the company or a project has just been completed. While valid approaches, these can suffer from losing the detail and context in which the knowledge has been developed and applied.

An alternative to post hoc capture of knowledge is to capture information and knowledge at 'source'. Reference is made to the gathering of knowledge as it is being created and used as 'process oriented' knowledge management (see Ref. [5]). The remainder of this paper describes the experience within British Nuclear Group Sellafield in the United Kingdom (formerly British Nuclear Fuels or BNFL) of what can be described as such a process oriented approach. The work described took place under an umbrella initiative of the Electronic Safety Case project that commenced in BNFL in 1997 [6].

4. CASE STUDY WITHIN THE CONTEXT OF SAFETY CASE DEVELOPMENT

The case study explored in this presentation concerned the production of 'engineering schedules' as part of a safety case process.

Within safety regulated industries, such as the nuclear industry, a safety case typically comprises a vast and complex set of inter-related records, documentation and knowledge. This information must be created, stored and maintained over several years. Within the United Kingdom nuclear industry, the safety case covers a set of safety related documentation that is produced throughout the life cycle of a plant, spanning plant design, commissioning, operation, modification and decommissioning.

A safety case comprises information that through its lifetime is generated, used and revised by a wide range of personnel and for a variety of purposes. Furthermore, creation of a safety case is typically a collaborative process involving, for example, plant operators, design engineers and safety engineers. In order to collaborate effectively, these different groups require an effective flow of information between each other, ensuring that information is shared in a timely manner and ensuring that the information is up to date.

Within BNFL/British Nuclear Group Sellafield, an engineering schedule — the focus of the case study presented here — is used to set out the list of safety equipment and their safety functions. For existing plants (as opposed to a plant under design and commissioning), the schedule is compiled collaboratively, involving plant operators, safety assessors and engineers. For a number of years, BNFL used a method or approach known as 'desktop studies' to draw up the engineering schedule for existing plants. Desktop studies involved all of the stakeholder groups in lengthy brainstorming sessions lasting weeks or months. In the desktop meetings, safety equipment and safety functions were considered and the engineering schedule drawn up. The engineering schedule, once complete, has a number of subsequent roles within the safety case, for example, it supports the creation of operating rules for a plant, the maintenance schedules and helps determine where further safety and engineering assessment is required.

In order to improve the way that the desktop study information was captured and managed, a database was constructed. This database was used to both drive the desktop meetings and to capture and report the data.

While development of the database required considerable effort in development and marketing the concept among the stakeholders of the safety case and engineering schedule process, it did deliver a number of key advantages:

— The database directly supported the task at hand (desktops and engineering schedule production). The desktop study was made more efficient and the gathering and managing of information more accurate.
— Once a number of plants' engineering schedules were gathered using the same database, it was possible to build up a corpus of schedule that could be 'queried' to ask questions such as:
  - What are the common fault scenarios for a plant/process like this?
  - What is the typical role of this kind of safety system?
  - What are the safety assumptions underpinning this piece of equipment?

- Which elements of the safety case will be impacted by a change to this piece of equipment?

In this mode, the application had the potential to become a valuable knowledge management tool.

5. SUMMARY AND CONCLUSIONS

The desktop database proved very successful. It not only provided a useful tool in supporting the desktop but it also provided a platform for further structured approaches (databases) to capturing information in other areas of the safety case development process.

In providing an example of process oriented knowledge management, a key success factor of the project was that it was based upon a detailed understanding of the business process (i.e. safety case development) in which the knowledge is being created and used. This understanding considered such aspects as the users or stakeholders, the flow and format of information, and the methodology surrounding the process.

A further success factor concerned the design of the application to support both the immediate task at hand and also the wider knowledge management aspects. In this way it was possible to overcome some of the 'resistance' that may have been encountered if the knowledge management application was perceived as an extra task, an extra burden, over and above the normal 'day job'.

REFERENCES

[1] SNOWDEN, D., "A framework for creating a sustainable programme", IBM Real Business Guide on Knowledge Management, 1998.

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Information Sheet L1-TM-27258, these Proceedings.

[3] Managing Nuclear Knowledge: Strategies and Human Resource Development (Summary Proc. Conf. Saclay, 2004), IAEA, Vienna (2006).

[4] http://www.mywiseowl.com/articles/Tacit_knowledge

[5] BERAHA, D., HEIGL, T., WESTERHEIDE, P., "Nuclear Knowledge Management: The GRS realization Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH Germany", Managing Nuclear Knowledge: Strategies and Human Resource Development (Proc. Conf. Saclay, 2004), IAEA, Vienna (2006).

[6] BRIGHT, C.K., "Electronic safety cases", Safety Cases (Int. Conf. London, 2001) IBC.

STRATEGIC PLAN FOR HUMAN RESOURCE MANAGEMENT AT THE CHILEAN COMMISSION FOR NUCLEAR ENERGY

L.E. PÉREZ ANDRACA, M. LICHTEMBERG VILLARROEL
Office of Planning and Management

Y. AUCAÑIR SALGADO
Personnel Section

Chilean Commission of Nuclear Energy,
Santiago, Chile

Abstract

Due to retirements and to a policy of no replacement of the retired workforce, the Chilean Commission for Nuclear Energy (CCNE) has had a gradual reduction of its personnel. The *current* average age of employees is about 45 years and is rapidly increasing. It is estimated that up to 80 CCNE employees (27%) will retire by 2015. In some specific areas of expertise, the retirement will be up to 55%. These conditions will adversely affect the execution of some institutional activities. Some interim actions to preserve or maintain knowledge have been developed and supported through a government programme in which a matrix map of institutional risk has been produced and a quality management system based on ISO 9001/2000 has been implemented. A future step is to develop a human resource management plan as a part of the CCNE Strategic Plan. This plan will provide for the implementation of the best practices and policies with regard to hiring, retention and retirement of essential personnel so as to maintain current CCNE capabilities and to implement a knowledge management system that would facilitate the identification, harvesting, preservation and transfer of knowledge produced at the CCNE.

1. INTRODUCTION

The Chilean Commission for Nuclear Energy (CCNE) was created in April 1964. It is a legal entity to protect the public interests as an independent State organization. CCNE is responsible for the development of science and nuclear technology in the country. It is an autonomous organization reporting to the Government through the Mining Ministry. CCNE is headed by an Executive Director who leads and coordinates the work of departments and advisory offices.

In order to carry out its functions and objectives, CCNE has about 300 employees and an annual budget of about US $9 million. Two research centres, each with a nuclear research reactor (CEN La Reina and CEN Lo Aguirre), are located to the east and the west of Santiago city, respectively. The Directorate of CCNE is in the downtown area.

The mission of CCNE is to promote research, development and applications of the peaceful uses of nuclear energy. Its regulatory functions include monitoring and control of nuclear and radiological safety and the authorization of operation of radioactive facilities, as well as the use of radioisotopes and radiopharmaceuticals. Other products and services include gamma irradiation services, analytical and physical characterization services, and implementation of advanced training courses on radiological safety and security. CCNE clients include governmental organizations, private companies, research institutions, universities, hospitals, clinics and industries, such as mining, nutrition and sterilized products.

2. PERSONNEL BACKGROUND

Until the end of July, CCNE had an effective personnel strength of 292 employees divided into five main categories: Directors, Professionals, Technicians, Administrative personnel and Support Services personnel. Staffing levels have been persistently diminishing with time (Fig. 1). The main reasons were retirement and the policy not to replace retired employees, enforced through a gradual reduction of the budget allocation. Specific problems that have arisen due to this situation include:

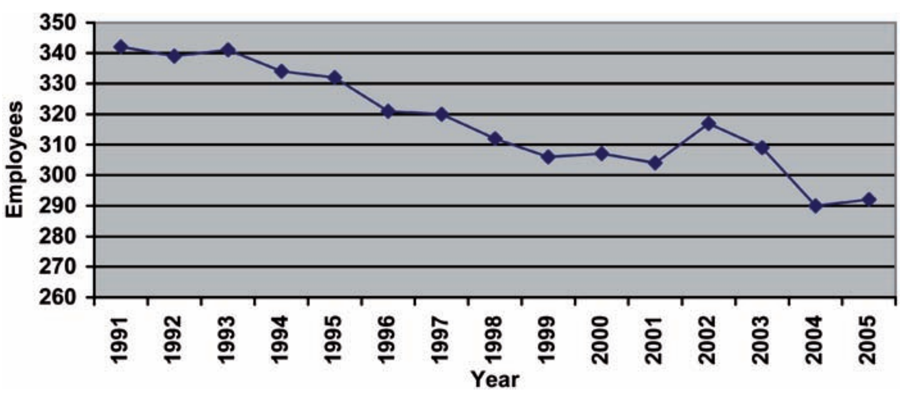

FIG. 1. Historical variation of CCNE's personnel (up to July of each year).

— Implementation of projects with inadequate personnel resulting in a lack of specialists to maintain continuity in the subject area and a lack of employment prospects for those of the younger generation interested in the study of nuclear subjects.
— Several 'unrelated units' being placed under the administration of one person. Other reasons for this phenomenon could be professional fervor, attempts to maintain future job security, and fears regarding the rapid global changes being experienced.

Table 1 shows the actual average age of employees by categories. Here, it is possible to see that all the categories have an average age of over 45 years. The average age is the highest for the two categories of employees (Directors and Professionals), who perform the main functions of the organization. This factor could lead to a critical situation in a few years if timely action is not taken.

According to current estimates, up to 80 CCNE employees would be retiring from service between now and 2015 (Table 2). The majority of them have already completed over 25 years of service in the organization. It may be observed that about 19% of the current Professionals would retire by 2010 and another 40% by 2015. In the case of Directors, nearly 55% of the current staff would retire by 2015.

The average age of all staff of CCEN has been gradually increasing as shown in Fig. 2. The decrease of average age in 2002 and 2003 is due to the fact that a large proportion of older employees retired during those years. For example, in 2003, when the State gave special incentives to encourage the retirement of government employees, all those above 70 years of age retired from the organization.

TABLE 1. AVERAGE AGE (JULY 2005)

Category	Total	Women	Men	Age average
Authority of Government and Directors	8	2	6	54.3
Professionals	151	44	107	49.4
Technicians	68	9	59	45.5
Administrative	59	32	27	45.7
Support	9	1	8	50
Age average		46	48.7	47.9

TABLE 2. HISTORICAL PERMANENCE AND POTENTIAL RETIREMENTS

Category	Total	Historical permanence		Potential retirements (year)	
		No. employees whose permanence ≥ 25 years	Average years per category	2010	2015
Authority of Government and Directors	8	6	27	2	5
Professionals	151	63	19	28	59
Technicians	68	19	18	7	15
Administrative	59	12	16	7	17
Support	9	1	18	3	4
Total	292	101	18	47	80

The gradual increase in the average age of staff at CCNE is mainly due to a lack of mobility of the employees, especially in the professional category. The reasons include:

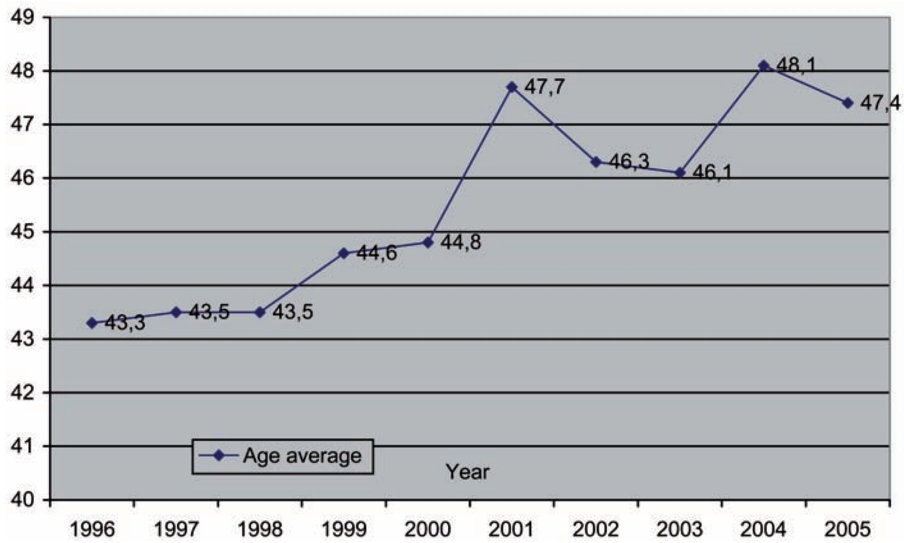

FIG. 2. Historical age average (up to July 2005).

- Better availability of economic resources and specialized equipment in CCNE in comparison with other Chilean research organizations and universities.
- Possibility of establishing professional bonds both within and outside the country that facilitate carrying out joint investigations and participating in research programmes financed by international organizations through coordinated research projects and research contracts.
- Lack of other employment opportunities for those who have specialized in the nuclear field, particularly those in the areas of nuclear safety, radioprotection and fuel cycle.
- State protectionism contributes to the lower mobility of government employees in comparison with those of the private sector.

The projected retirement of professionals and technicians up to 2015 is 33% of the current value (Table 3).

Based on this information, it is easy to predict that the execution of core institutional activities would be adversely affected by inadequate human resources over the medium and long term, if suitable actions are not taken urgently to preserve the knowledge acquired so far in the diverse areas of CCNE activities.

3. INTERIM ACTIONS

The CCNE has reviewed the situation caused by the continuing depletion of human resources and recognized the following basic principles:

- Human resource is the main capital of institutional knowledge, information and data acquired so far, and are important and need to be preserved. It is necessary to learn how to manage knowledge in the face of new global challenges. Appropriate emphasis has to be placed on knowledge and basic competencies of new recruits. The core competencies of CCNE would have to be continuously reinforced through training systems. The knowledge and technologies developed would have to be applied to generate new products and to improve current products and processes. The Government has launched a programme on ‘public management improvement’ with the objective of an integral development of strategic aspects of management of the public sector, such as human resources, user satisfaction, planning and finance. At CCNE, this programme has been used to identify areas of weakness and areas requiring improvement.

TABLE 3. RETIREMENT OF PROFESSIONALS AND TECHNICIANS UP TO 2015

Category or area	Total (%)
Directors	50
Nuclear and radiological safety	17
Radiological and environment protection	41
Nuclear applications	35
Nuclear materials	42
Plasma	0
Production and services	29
Systems and administration	28
Consulting units	47
Total	33

— A matrix map of institutional risk has been prepared. The map will allow the institutional authorities to identify the areas of technical and administrative risks. Depletion of human resources has been recognized as the single major risk to the proper functioning of the organization.
— The importance of implementing a quality management system based on ISO 9001/2000 has been recognized for certifying those products and/or services considered strategic by the institution. In the medium term, it is hoped to implement a quality integrated system under ISO 9001 and 14000, and the Occupational Health and Safety Assessment Series OHSAS (18001). The results obtained so far include certification of several strategic institutional processes, products and services; implementation of procedures, work instructions, traceability and the implementation of an effective organizational *structure*.

Other actions that have been taken include obtaining group commitments through ‘work contracts’; providing performance incentives for the fulfilment of goals; and a qualification programme with qualification standards according to hierarchic levels. Finally, a strategic plan for the CCNE is currently being developed.

4. CONCLUSION AND FUTURE STEPS

In conclusion, it may be said that the human resources situation at the CCNE has been recognized as posing a high risk to the future viability of the institution and that remedial actions are urgently needed to mitigate the consequences.

The next step proposed is to elaborate a human resource management plan under the CCNE Strategic Plan. The objectives of this plan are to:

— Establish the competence profile of the ‘national expert’ in the nuclear and radiological sector, and to quantify those factors that give form and/or affect that profile.
— Implement human resource management practices in an integrated manner with the processes of planning, programming, budget allocation and evaluation.
— Implement instruments or policies regarding hiring, maintenance and retirement of the necessary personnel to maintain CCNE capabilities.
— Implement a nuclear knowledge management system in order to facilitate the identification, harvesting, preservation and transfer of knowledge produced at the CCNE.
— Implement a system of incentives to achieve CCNE’s goals, objectives and mission.

APPROACH OF TVA NUCLEAR TO RETAINING CRITICAL KNOWLEDGE IN AN AGEING WORKFORCE

J.E. BOYLES
Tennessee Valley Authority,
Chattanooga, Tennessee, United States of America

Abstract

In 2002, TVA Nuclear developed and implemented a process to retain critical knowledge and skills that could be lost due to attrition. By the late 1990s the average age of the workforce was approaching 47 years and the average age of retirement was 55 years. It was evident that over the next five to ten years, attrition would result in the loss of a significant number of experienced workers. In fact, approximately 35% of the workforce has retired over the past six years and, based on current projections, an additional 35% will be eligible to retire within the next five years. In addition, many of the incumbent employees possess critical knowledge and skills gained over a career of building and operating TVA's nuclear facilities. The 'knowledge retention' process was developed to identify and retain this critical knowledge and skill that contribute to the organization's performance. The process consists of the following steps: assess and prioritize the risks of losing critical knowledge and skills; develop and implement plans to capture critical knowledge or adapt to its loss; and monitor and evaluate action plans and priorities. The three step process is one element of an overall strategic approach to workforce management, which includes workforce planning, recruiting, training, leadership development and knowledge retention.

1. BACKGROUND

Tennessee Valley Authority (TVA) had voluntarily shut down its five operating nuclear units in 1985 to address safety concerns. The restart of the Sequoyah Unit 1 (November 1988) began a shift in focus from restart and recovery to an operations mode. With the startup of Watts Bar Unit 1 in 1996, the shift to an operations organization was virtually complete. This led to a dramatic decline in staffing from a peak of almost 14 000 in 1988 to just over 3300 in 1997. During this transition, very little recruiting of new employees occurred.

During the period 1995–1997, management commissioned independent staffing benchmark studies to develop future staffing targets. These benchmark studies compared TVA's nuclear plants to other best performing plants in the

United States of America. After the benchmark studies were completed, management began a systematic analysis of the existing workforce in order to develop long term staffing plans. Under TVA's retirement system, employees who had reached an age and length of service equal to 80 (Rule of 80) could retire with full pension benefits. This allowed many employees to retire at a relatively early age. The initial demographics data indicated that a large percentage (35–40%) of the workforce could retire over the next five years. In addition, the knowledge and skills requirements of the workforce continued to change as a result of technology advancements, process improvements and the continued efforts to raise the level of performance in the nuclear organization. Based on these factors, the focus for management in the area of workforce planning now included developing and maintaining critical skills, the retention of critical knowledge, and recruiting and training new talent.

To address these issues, the management of TVA Nuclear developed a strategic approach to manage this ageing workforce challenge. The programme was called the Integrated Staffing Plan and included the following elements:

— Workforce planning;
— Recruiting plans;
— Pipeline training programmes;
— Leadership development/succession planning;
— Knowledge retention.

2. KNOWLEDGE RETENTION PROCESS AT TVA NUCLEAR

As noted, the three step process begins with assessing and prioritizing the risks of losing critical knowledge and skills.

2.1. Step 1: Conducting knowledge loss risk assessments

Attrition related threats of knowledge loss are initially assessed by determining the 'total risk factor' for each incumbent in the organization. This total risk factor is based on time until retirement ('retirement factor') and criticality of knowledge and skill ('position risk factor').

The 'retirement factor' is based on the projected retirement date in the workforce planning system (whether based upon employee estimates, supervisor estimates or calculated based on age and tenure data). Table 1 shows how a retirement factor is assigned.

The 'position risk factor' is based on the criticality of knowledge and skill possessed by the incumbent and an estimate of the difficulty or level of effort

TABLE 1. CALCULATING THE RETIREMENT FACTOR

Retirement factor	Criteria
5	Projected retirement date within current fiscal year or next fiscal year
4	Projected retirement date within 3rd fiscal year
3	Projected retirement date within 4th fiscal year
2	Projected retirement date within 5th fiscal year
1	Projected retirement date within or greater than 6th fiscal year

required for refilling the position. Managers are responsible for initially providing these ratings. They should consider each employee’s responsibilities and background, formal and informal roles, collateral duties and re-occurring assignments (e.g. outage related duties, problem solving or troubleshooting assignments) and other factors suggesting that the employee may have unique and/or critical knowledge and skills. Managers may want to consult other work group members, key plant customers or interested parties. Managers summarize this assessment by providing a position risk factor based upon the criteria shown in Table 2.

The ‘total attrition factor’ provides an overall assessment of attrition related risk of knowledge loss. The total attrition factor is computed by multiplying the retirement factor by the position risk factor. Table 3 shows an example.

TVA’s workforce planning system will automatically calculate the total attrition factor based on the Retirement Factor and Position Risk Factor. Reports are available for each organization down to the department level. Each organization’s management team is responsible for collectively reviewing the position risk factors and resulting total attrition factors. Changes are communicated to the human resources area and reflected in the workforce planning system.

Each organization’s management reviews the total attrition factors of its employees and prioritizes the risks. Guidelines for these priorities are outlined in Table 4.

Management teams identify where a knowledge retention plan is needed and assign responsibility for plan development (typically, the employee’s supervisor or manager).

TABLE 2. CALCULATING THE POSITION RISK FACTOR

Position risk factor	Criteria
5	Critical and unique knowledge or skills. Mission critical knowledge/skills with the potential for significant reliability or safety impacts. TVA Nuclear or site-specific knowledge. Knowledge undocumented. Requires 3–5 years of training and experience. No ready replacements available.
4	Critical knowledge and skills. Mission critical knowledge/skills. Some limited duplication exists at other plants or sites and/or some documentation exists. Requires 2–4 years of focused training and experience.
3	Important, systematized knowledge and skills. Documentation exists and/or other personnel on-site possess the knowledge/skills. Recruits generally available and can be trained in 1–2 years.
2	Proceduralized or non-mission critical knowledge and skills. Clear, up to date procedures exist. Training programmes are current and effective and can be completed in less than one year.
1	Common knowledge and skills. External ‘hires’ possessing the knowledge/skills are readily available and require little additional training.

2.2. Step 2: Develop and implement plans to capture critical knowledge or adapt to its loss

The process for determining and implementing the most appropriate method(s) for addressing potential knowledge loss involves:

— Making an inventory of the specific knowledge and skills of the identified employee;

TABLE 3. CALCULATING THE TOTAL ATTRITION FACTOR (AN EXAMPLE)

Projected retirement within 1 year	Retirement factor =	5
Critical/unique knowledge/skills	Position risk factor =	5
Total	Total attrition factor = 5×5 =	25

— Assessing the criticality of each area of knowledge/skills;
— Developing knowledge retention plans;
— Coordinating and reviewing knowledge retention plans;
— Implementing knowledge retention plans.

Human resources (particularly human resource consultants) are available to assist in the development of knowledge retention plans. Resources are also available on the human resource area's 'retaining critical knowledge' intranet web site.

Managers compile a list of potential knowledge loss areas for each included position or incumbent. Typically, this includes discussion with the employee. In compiling this list, managers should consider the employee's responsibilities and background, formal and informal roles, collateral duties and re-occurring assignments (e.g. outage related duties, problem solving or troubleshooting assignments) and any other unique and/or critical knowledge and skills. Such knowledge or skills can be of many different types: task and equipment related knowledge and skill; facts or information about specific people, vendors, projects and locations; and unique pattern recognition knowledge and problem solving skills.

TABLE 4. GUIDELINES FOR TOTAL ATTRITION FACTOR PRIORITIES

Total attrition factor	Priority
20–25	High priority: Immediate action needed. Specific replacement action plans with due dates will be developed to include knowledge retention plan, knowledge management assessment, specific training required and on the job training or shadowing with incumbents.
16–19	Priority: Staffing plans should be established to address method and timing of replacement, recruitment efforts, training and shadowing with current incumbent.
10–15	High importance: Look ahead on how the position will be filled or work will be accomplished. College recruiting, training programmes, process improvements and reinvestment.
1–9	Important: Recognize the functions of the positions and determine the replacement need.

2.3. Step 3: Monitor and evaluate action plans and priorities

At least semi-annually, the implementation of the knowledge retention process is reviewed. Specifically, management teams:

— Review previous knowledge retention plans and progress;
— Identify any positions or incumbents for reassessment or knowledge retention plan development;
— Identify related emerging issues or points of coordination;
— Review knowledge retention metrics, including:
  - Number of high priority positions;
  - Number of positions targeted for knowledge retention plan development;
  - Number of positions with a current knowledge retention plan;
  - Status of knowledge retention plans (complete, on-track, etc.);
  - Knowledge related organization metrics (human performance, safety, etc.).

These reviews may occur as part of other site meetings (site succession planning or site leadership review meetings).

3. LESSONS LEARNED

Typically there is less at-risk critical knowledge than suspected. Often redundant resources are identified during the risk assessment or implementation of the knowledge retention plan. The risk is greatest in specialized technical positions which utilize problem solving strategies.

Current procedures may be weak, relying on experienced personnel rather than on strong processes and detailed work plans.

A range of options exists to mitigate knowledge loss. These options include codification, use of alternate resources, 'engineer-it-out' and education or training.

4. SUMMARY AND CONCLUSIONS

The knowledge retention process has been successful in identifying the potential for loss of critical knowledge and skills within TVA Nuclear. The process is simple and straightforward, providing site management with a tool that can quantify risk and address necessary steps to mitigate the potential knowledge loss. As with most management processes, implementation is often the weak link necessitating periodic monitoring and updating (Step 3).

Additional information about the TVA knowledge retention process is available at the TVA web site (http://www.tva.gov/knowledgeretention/).

MANAGING AND PRESERVING KNOWLEDGE IN THE NUCLEAR SECTOR

(Session 4)

Chairperson

A. KOSILOV
IAEA

KNOWLEDGE PRESERVATION FOR NUCLEAR POWER PLANTS

A. KOSILOV
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

The IAEA is developing guidance documents on nuclear knowledge management, including knowledge preservation and knowledge transfer in the nuclear sector. This activity will assist nuclear organizations in Member States to effectively apply this guidance and benchmark their practices against those of other industry organizations. The first technical meeting to develop a guidance document on the preservation (and enhancement) of nuclear knowledge for nuclear power plant operating organizations was held 14–17 June 2004 in Vienna. As a result, a preliminary draft document on the subject, prepared by the IAEA Secretariat, was reviewed and the outline of the new technical document developed. The IAEA would ensure close coordination with other international nuclear organizations that are working on nuclear knowledge management. The paper describes the IAEA role in assisting Member States in the preservation of nuclear knowledge and the steps being taken to develop a guidance document for nuclear power plant operating organizations.

1. BACKGROUND

There is an immediate need to preserve for future generations the existing knowledge in nuclear science and technology for peaceful applications, as it represents a valuable human capital asset. The development of an exciting vision for nuclear technology is a prerequisite for attracting young scientists and professionals to seek careers in nuclear science and technology.

Irrespective of current national energy policies, the need to maintain or even enhance the nuclear knowledge base and national capability will persist. The knowledge would also assist in meeting the requirements for policy development. A number of IAEA advisory committees and technical meetings stressed the importance of preserving and further enhancing nuclear science and technology for socioeconomic development. For nuclear science and technology to make a substantial contribution to sustainable development, knowledge and capacity are required on three levels:

(1) Basic nuclear science;
(2) Technology;
(3) Engineering and operation.

The IAEA has an obligation to take the lead in the preservation and enhancement of nuclear knowledge by complementing and, as appropriate, supplementing activities by governments, industry, academia and international organizations. International cooperation is of vital importance. Unless action is taken now, critical nuclear knowledge and capacity, invaluable assets built up over the last half a century, will soon be lost.

The need to sustain the present level of deployment of nuclear technology (energy and non-energy alike) requires urgent action throughout the nuclear community and beyond. The IAEA, in particular, is expected to use its potential in assisting Member States to ensure the preservation of viable nuclear education and training which is a necessary prerequisite for succession planning. The needs may be even more pressing in Member States that consider expanding nuclear programmes as an essential component for meeting the national sustainable development goals.

The IAEA is developing guidance documents on nuclear knowledge management, including knowledge preservation and knowledge transfer in the nuclear sector. (For documents already published see http://www.iaea.org/Publications/index.html.) This activity would assist nuclear organizations in the Member States to effectively apply this guidance, and benchmark their practices against those of other industry organizations.

2. OUTCOMES FROM THE FIRST TECHNICAL MEETING HELD IN JUNE 2004

A new technical document on preservation and enhancement of nuclear knowledge for nuclear power plant operating organizations is under preparation. The document will identify the fundamental elements needed for an effective knowledge management system and provide guidance on methods for knowledge management implementation. The target audience for this document would be senior managers of nuclear power plant operating organizations up to and including the Board of Directors. For this audience, knowledge management is important due to the very long (100 years or more) life cycle of a nuclear power plant and the extensive knowledge needed to effectively and safely manage all its phases. Thus, knowledge management needs to be an essential part of the long term strategy of the organization. Additionally, through knowledge management:

— Operational and safety performance can be improved;
— Operational and personnel safety risks can be reduced;
— Re-engineering opportunities can be identified.

Collectively, these results should lead to improved business performance.

While there is no universally accepted definition of knowledge management, for the purposes of this document, knowledge management is defined as a systematic process of finding, selecting, organizing, distilling, validating and presenting knowledge in a way that improves an employee's or organization's comprehension in a specific area. For a nuclear power plant operating organization, specific knowledge management activities help focus the organization on acquiring, storing and utilizing knowledge for such things as effective transfer of knowledge from an ageing workforce to the next generation, problem solving, dynamic learning, strategic planning and decision making.

Knowledge management is quite a recent concept, having come to prominence during the 1990s. However, due to the nature of nuclear power plant operating organizations (high hazard but low risk), a number of plant activities and programmes have been in place throughout the industry to manage and control the knowledge and information related to nuclear power plant design, construction, operation and maintenance. Examples of existing knowledge management activities for nuclear power plant operating organizations include:

— Configuration management;
— Document control;
— Work control systems;
— Quality assurance and quality management;
— Operating experience programmes;
— Corrective action systems;
— Safety analysis;
— Training and development;
— Human resource management.

Knowledge management implementation is not intended to replace any of these systems, but rather should increase the benefits from these systems through providing an integrated approach to:

— Increasing the value of existing knowledge;
— Collecting, developing and integrating tacit knowledge;
— Identifying business, operational and safety risks due to knowledge gaps.

If properly implemented, knowledge management should not ‘take over’ any existing plant programmes or activities, but rather should be a catalyst to increase the benefits to the organization of these activities. The lessons learned in the nuclear industry in the past 20 years in moving from inspecting quality through large quality assurance organizations to building quality into all plant processes (with associated reductions in the number of quality assurance auditors/inspectors), have considerable relevance for knowledge management implementation.

If we look five or ten years into the future, the success of knowledge management for nuclear power plant operating organizations should not be measured by whether or not there is a Knowledge Management Officer or a large knowledge management organizational unit, but rather that knowledge management ideas are a part of the daily life, practices and culture of nuclear power plant operating organizations, and that knowledge management methods are being used to make established processes more effective for managing knowledge and information.

In June 2004, the IAEA organized a technical meeting to develop a guidance document on the preservation (and enhancement) of nuclear knowledge for nuclear power plant operating organizations. The meeting participants provided inputs for a proposed outline of the technical document. The draft document developed by the IAEA would be reviewed by a small number of nuclear power plant operating organization managers who have not been involved with its development in order to ensure that it is presented and organized in a manner that will be most suitable for the target audience. The IAEA has a close coordination with other international as well as national nuclear organizations that are working on knowledge management. These include the Nuclear Energy Institute (NEI), Organisation for Economic Co-operation and Development/Nuclear Energy Agency (OECD/NEA), World Association of Nuclear Operators (WANO), Institute for Nuclear Power Operations (INPO) and Electric Power Research Institute (EPRI). For example, the Nuclear Human Resource Group (NHRG) Community of Practice under the NEI is considering a workshop later this year at INPO Headquarters in Atlanta, United States of America.

It was indicated that there would be considerable benefit for nuclear power plant operating organizations to have access to IAEA services to assist in the implementation of knowledge management fundamentals and guidelines being developed. The nature of these services could be a combination of ‘communities of practice’, benchmarking and assisted visits and missions. As developments in knowledge management are moving quite rapidly, both within the nuclear power industry and in other relevant industries, the IAEA would develop and maintain a database of examples of good practices in knowledge management, rather than providing them as annexes or appendices in the proposed technical document (e.g. web space with password control). In that way, the information can be kept current and quickly reflect new developments in this field. Examples would be provided in all areas for which methods are discussed in the guidelines and as many application areas as possible (e.g. document control, work control, configuration management, training, human resources, operating experience, corrective action systems, etc.) would be addressed.

3. THE NEXT STEPS

The second meeting on the subject will take place in December 2006. The meeting will provide a forum for presentations and discussions regarding practical methods being used or developed today for knowledge management in nuclear power plant operating organizations, and will review the proposed IAEA technical document on knowledge management for nuclear power plant operating organizations. The draft document is expected to be completed in 2005.

KNOWLEDGE MANAGEMENT REVIEW CRITERIA

T. MAZOUR
Nuclear Power Engineering Section

A. KOSILOV
INIS and Nuclear Knowledge Management Section

Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

The paper presents knowledge management review criteria, which are intended to be used by a nuclear power plant operating organization in conducting a self-assessment or an external review of knowledge management functions. Most of these criteria have been used by IAEA experts during the missions on knowledge management at Krško nuclear power plant, Slovenia and Kozloduy nuclear power plant, Bulgaria.

1. INTRODUCTION

The following guidelines are intended to be used either by a nuclear power plant operating organization in conducting a self-assessment of its knowledge management functions, or for an independent, external review of a nuclear power plant operating organization. These criteria are not so much intended to provide a 'report card' as they are to help managers to identify strengths to build upon and weaknesses to be addressed in the knowledge management area. The criteria are grouped as follows:

(1) Knowledge management policies and strategies;
(2) Knowledge management methods and techniques.

Tables 1–10 focus on aspects of the criteria in more depth.

2. DEFINITION OF KNOWLEDGE MANAGEMENT

'Knowledge management' is defined, in this document, as an integrated, systematic approach to identifying, managing and sharing an organization's knowledge, and enabling persons to create new knowledge collectively and thereby help achieve the objectives of that organization [1, 2].

3. CRITERIA AND GUIDELINES FOR SELF-ASSESSMENT OF KNOWLEDGE MANAGEMENT FUNCTIONS

The criteria and guidelines for an assessment of knowledge management functions in nuclear power plant operating organizations are given in the following samples of forms (see Tables 1–10).

The particular areas of interest include:

— Knowledge management policies and strategies;
— Knowledge capture/transfer methods and techniques;
— Training and qualifications;
— Communication methods and techniques;
— Human resource management;
— Methods for effectively learning from operating experience;
— Work control methods to facilitate knowledge management;
— Human performance improvement;
— Implementing procedures and documentation;
— IT solutions supporting knowledge management.

TABLE 1. SAMPLE FORM FOR KNOWLEDGE MANAGEMENT POLICIES AND STRATEGIES

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	Top level policies and associated procedures provide an integrated strategy and implementing approach for knowledge management, including identification of roles and responsibilities for knowledge management. This knowledge management strategy is linked to the organization's business plan such that knowledge management is used as a tool for continuous improvement in the organization's performance.											
2	A communications strategy is in place that supports the organization's mission and change initiatives by identifying objectives, strategies and tactics for communicating with key stakeholders. This strategy includes communications related to the value and importance of knowledge management to the organization.											
3	A workforce planning strategy has been developed to ensure that staffing needs for the life of the organization are identified and tracked. This strategy addresses areas such as risks associated with losing mission critical knowledge, succession planning and developing leaders and managers.											
4	A human performance improvement programme is established to continually identify opportunities to improve plant performance and expand the knowledge of the organization, particularly for those activities related to safe and reliable plant operation.											
5	Strategies for knowledge transfer and retention should be developed and implemented to preserve unique knowledge and skills that could be lost through attrition or planned staffing changes.											
6	An effective process is established that clearly defines expectations for procedure use which takes into account the complexity of the task, the skill and training of plant personnel, the extent of supervisory involvement and the potential consequences of improper performance.											

TABLE 1. SAMPLE FORM FOR KNOWLEDGE MANAGEMENT POLICIES AND STRATEGIES (cont.)

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
7	Senior corporate and plant managers, through personal involvement, foster open communications — up, down and horizontal.											
8	The culture of the organization promotes the transfer of knowledge, particularly tacit knowledge among plant personnel. Evidence of this culture is seen through: (1) managers serving as role models for others to emulate regarding knowledge transfer; and (2) mutual trust existing between managers and the workforce, including trade unions, if applicable. Methods are in place to periodically assess the status of this culture.											
9	Managers are personally involved in ensuring that the knowledge management programme is developed, implemented, continuously improved and integrated with the organization's overall management system.											
10	A strategy has been developed to reward and recognize people for their contributions to 'growing' the knowledge assets of the organization.											
11	Benchmarking is an established policy to transfer knowledge, improve performance and emulate best industry practices. Identification and correction of problems and use of operating experience, benchmarking and self-assessment should be integral to the organization's culture.											
12	Managers have established a continuous learning environment that encourages employees to improve individual and station performance.											

TABLE 2. SAMPLE FORM FOR KNOWLEDGE CAPTURE/TRANSFER METHODS AND TECHNIQUES

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	Effective use is made of knowledge elicitation tools to assist in identifying critical knowledge held by employees/experts, to present this knowledge in a manner that facilitates its transfer to others and to ensure that elicited knowledge is both current and validated.											
2	Plant personnel document and transfer information accurately. Plant activities, conditions and decisions are documented in sufficient detail to enable personnel to recreate and address plant problems or events.											
3	Managers and co-workers frequently observe work and training activities to ensure that knowledge capture and transfer methods are being effectively applied and to identify needed improvements.											

TABLE 3. SAMPLE FORM FOR TRAINING AND QUALIFICATIONS

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	A systematic approach to training (SAT) is implemented to achieve, maintain and improve personnel knowledge, skill and performance to support plant safety and performance goals.											
2	Managers feel accountable for the training, qualifications and performance of their personnel. They use appropriate tools (e.g. qualification matrix) to assist them in determining whether they have adequate numbers of qualified persons to assign to tasks important for safe and reliable operations.											
3	Managers understand their roles in carrying out the organization's 'knowledge management programme' and assign developmental activities, coach personnel, and counsel individuals to improve their performance.											
4	Continuing training, including 'just in time' training ensures that plant personnel maintain their job specific knowledge and skills.											
5	Contractor personnel involved in plant activities and assigned to work independently perform to the same standards as the plant staff and are verified to have the specialized skills and training appropriate to the tasks they perform. Responsibilities are established for the oversight of contractor personnel who work independently.											
6	Training materials and examinations are current, accurate and of high quality.											

TABLE 4. SAMPLE FORM FOR COMMUNICATION METHODS AND TECHNIQUES

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	Managers practise visible leadership in the field by personally observing performance, coaching, mentoring and reinforcing standards.											
2	Managers encourage cooperation and teamwork among plant organizational units, especially when successful implementation of work activities requires support from several groups.											
3	The organization's values and behaviours are modelled by its leaders and practised by all plant staff. Effective mechanisms are in place to promptly transfer these values and expected behaviours to new staff.											

TABLE 5. SAMPLE FORM FOR HUMAN RESOURCE MANAGEMENT

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	Managers ensure that future staffing needs are identified and tracked through an ongoing workforce planning process. This planning process includes a knowledge loss risk assessment that identifies knowledge that is critical to the organization's mission and that may be lost in the near future.											
2	A profile defining the competencies needed for key jobs is established and used to identify candidates for leadership positions and to guide their development.											
3	Succession plans are in place for key corporate and plant positions. The succession plan includes rotational assignments, project assignments and other means to develop staff for advancement.											
4	Candidates for leadership positions are developed through training and assignments in a variety of positions within the organization. On an ongoing basis, senior nuclear managers assess the progress of individuals identified as having management and leadership potential and their readiness for future management positions.											
5	Human resource personnel work as a team with line managers to anticipate personnel needs and recruit to ensure sufficient staffing of knowledgeable and skilled personnel.											

TABLE 6. SAMPLE FORM FOR METHODS FOR EFFECTIVELY LEARNING FROM OPERATING EXPERIENCE

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	A process is in place to encourage, monitor and address employee feedback on knowledge management and other organizational initiatives.											
2	Plant personnel are self-critical and frequently provide feedback to improve knowledge management processes, plant performance, processes, plans, procedures and training. They willingly report problems, near misses, error-likely situations and safety hazards.											
3	Lessons learned from operating experience are institutionalized through changes to station processes, procedures, equipment and training programmes.											

TABLE 7. SAMPLE FORM FOR WORK CONTROL METHODS TO FACILITATE KNOWLEDGE MANAGEMENT

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	Knowledge management methods, wherever practical, are built into processes, rather than being separate, add-on tasks in order to increase effectiveness and reliability of knowledge capture and transfer.											
2	The composition of operating crews and other teams takes into account individual experience and attributes to enhance knowledge transfer.											
3	Maintenance, operations, engineering and other work groups have an effective, integrated role in monitoring plant performance and in documenting this knowledge in such a way that it can be effectively retrieved and utilized when needed.											

TABLE 8. SAMPLE FORM FOR HUMAN PERFORMANCE IMPROVEMENT

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	Change initiatives are well managed and coordinated. The potential effects of organizational changes and staff reductions are considered and addressed before such changes are initiated.											
2	There is a feedback process, including post job reviews and management observations, to improve human performance and knowledge transfer.											

TABLE 9. SAMPLE FORM FOR IMPLEMENTING PROCEDURES AND DOCUMENTATION

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	Plant procedures are a logical location in which to store knowledge that is captured from experts. However, the inclusion of such knowledge in procedures is structured in such a way that information about why something is done does not detract from the effective and reliable use of the procedure.											
2	Plant procedures, particularly emergency and abnormal procedures, are written in accordance with applicable owners' group guidance, plant-specific guidelines, plant-specific probabilistic safety analyses and vendor technical manuals.											
3	Design calculations, drawings, analyses, procurement specifications and other design documents are readily retrievable and clearly describe the bases for the function of plant systems and components.											
4	Licensing and design requirements are well defined, documented, controlled and retrievable.											
5	Procedures, drawings, training lesson plans and related documentation are updated promptly following implementation of configuration changes.											

TABLE 10. SAMPLE FORM FOR IT SOLUTIONS SUPPORTING KNOWLEDGE MANAGEMENT

No.	Description of criteria	Exists in my organization (1 = not at all to 5 = fully)					Important to my organization (1 = low to 5 = high)					Comments
		1	2	3	4	5	1	2	3	4	5	
1	The organization's IT strategy is based upon achieving its knowledge management objectives.											
2	Information technology is used effectively to capture and share knowledge critical to the organization's mission.											
3	IT products and services are developed based upon customer knowledge management needs.											
4	It is recognized that not all knowledge management needs can be addressed through IT solutions.											

REFERENCES

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, Knowledge Management for Nuclear Industry Operating Organizations, IAEA-TECDOC-1510, IAEA, Vienna (in preparation).

[2] http://www.iaea.org/km

THE GERMAN APPROACH TO NUCLEAR KNOWLEDGE MANAGEMENT

M. PETRI
Federal Office for Radiation Protection (BfS),
Arbeits Gruppe Forschungs Koordinierung,
Salzgitter, Germany

Abstract

Germany faces a difficult situation. The German Government has decided to phase out nuclear energy as a source for electricity production. As a consequence of this decision, the 17 nuclear power plants currently in operation will be gradually disconnected from the grid within the next 15–20 years. During the whole phase out period, Germany has to maintain the capability to safely operate its nuclear power plants, to dismantle the shut down plants and to solve the problem of radioactive waste disposal in a scientifically and socially satisfactory way. The generation of experts that has participated in the construction or commissioning of nuclear power plants in Germany is currently reaching its retirement age. Due to the steady shrinkage of the German nuclear sector, not all retiring experts can be replaced. The reduced job prospects have resulted in a dramatic decline of the number of students enrolling in nuclear sciences. Therefore, it is very difficult to find replacements with the required education in nuclear technology. Under these circumstances, it is a great challenge for the industry, utilities and regulatory authorities to transfer the essential knowledge of the retiring experts to the remaining workforce. Knowledge management is regarded by the German Government as a key to preserving the necessary knowledge within the utilities and the regulatory body. A centralized coordination of knowledge management activities is particularly challenging in Germany because of the complicated regulatory structure. The regulatory body in Germany consists of a complicated network of Federal and state authorities with their respective technical support organizations. Every organization within this network is organizationally independent and thus has its own say on how to implement knowledge management programmes and strategies. The paper presents the knowledge management activities at the Federal level. The German situation and the key problems faced in Germany are briefly outlined. Ongoing knowledge management activities within or sponsored by the German Government are briefly described. The paper focuses on two key aspects: (a) to strengthen the educational sector by promoting the enrolment of students in nuclear sciences and providing adequate research opportunities; and (b) to identify and preserve the essential knowledge within the regulatory body and its technical support organizations by advanced information and knowledge management techniques.

1. THE GERMAN SITUATION — TRENDS AND FACTS

Since 1980, there has been stagnation in electricity consumption in Germany. Key contributors to this effect were the relatively low growth rates of the German economy in these years and the successful attempts to increase the efficiency of use of energy. An unforeseen decline in industrial production in Eastern Germany shortly after the reunification also contributed to the stagnation in the 1990s. Due to lack of demand there was no incentive to build new power plants. The last nuclear power plant was connected to the grid in 1989. At the same time, developments outside of Germany, e.g. the Three Mile Island and Chernobyl accidents, created an unfavourable atmosphere for nuclear energy production in Germany.

The reduced economic growth prospects in the industrial sector in general, and the electricity producing sector in particular, resulted in consolidation processes (mergers, downsizing, etc.) with the consequence of severely reduced job prospects in the nuclear sector. The growing negative public attitude towards nuclear energy production, combined with the decreasing industrial interest in this field, had negative consequences on governmental and industrial funding of nuclear research, so that the main research centres in the nuclear field were forced to reorient their middle and long term research perspectives towards non-nuclear activities. In an environment where industrial and research activities are driven down, it is difficult to attract students. The dramatic reduction within the last ten years of students enrolled in nuclear sciences resulted in further budgetary constraints for nuclear oriented research and education in universities, due to the fact that university funding is strongly dependent on the number of students.

2. THE GERMAN SITUATION — FACING SPECIFIC PROBLEMS

Retiring experienced regulators have to be replaced or their knowledge disseminated into the regulatory organization without compromising its capability to perform its regulatory functions. Decreasing job prospects in the nuclear sector, diminishing numbers of students and related problems are phenomena that are common to almost all countries that have an advanced nuclear programme. Yet each country has some specific problems of its own.

A specific problem for the regulatory body in Germany is that, being part of the Federal Government, the regulatory body is subject to the obligation of all governmental institutions to generally reduce their staff by 1.5% per year. This obligation was introduced in the 1990s in order to cut down the large number of civil servants that had to be assimilated into the Federal

Government because of the reunification. However, due to budgetary constraints, the annual cuts continue although the goal to reduce personnel to the number of government employees before reunification has long been reached. Therefore the staffing levels in the regulatory body have been constantly shrinking at a higher rate than the workload it has to perform.

Although it is still possible to hire new staff, it is difficult to find experienced staff. The regulatory body and its technical support organizations recruit their new personnel mainly from the universities. With the dramatic decline of students enrolled in the nuclear sciences, there are practically no new nuclear scientists or engineers left to recruit. Therefore newly hired personnel often did not receive any specific nuclear education and they require additional training on the job. Even if staff members can be hired who were exposed to nuclear courses in university, those newly hired in general do not have any practical experience. This has to do with the fact that experimentally oriented nuclear research requires expensive equipment and an environment that is generally favourable towards the development and implementation of new nuclear techniques. Germany lacks such an environment. Due to the lack of governmental or industrial funding, the universities and research centres have driven down their practice oriented research activities in the nuclear sciences, so that nuclear education is becoming increasingly theoretical.

Another problem specific to Germany is the complicated regulatory system, consisting of (a) external authorities not belonging to the state that is directly responsible for the licensing and supervision of the nuclear plants within the states; and (b) Federal authorities that coordinate and supervise the state activities. As every state authority is fully responsible for the nuclear installations within its territory, every state has to make sure that it can perform the full spectrum of regulatory activities, even if it only has one nuclear installation left under its custody. In order to allocate resources efficiently, the German approach has been to keep the personnel at the regulatory body to a minimum and to rely strongly on the technical support organizations for specific technical or scientific expertise. However, with nuclear installations being successively shut down, the German system is becoming increasingly inefficient due to the large number of authorities and expert organizations that the regulatory body has to rely on. Although resources can be combined in principle, it is particularly difficult to pool resources at the state and Federal level. Within a federally organized system, the Federal and the state authorities do not always have identical objectives and — for legal or practical reasons — often consult different technical support organizations. Furthermore, knowledge management activities are difficult to organize or to coordinate, because each state authority is organizationally independent. The natural tendency of the states to keep the Federal influence at a minimum is not always helpful when the overall situation requires federally coordinated actions.

3. KNOWLEDGE MANAGEMENT ACTIVITIES AT THE FEDERAL LEVEL

At the current time there are three main lines of activities at the Federal level, as outlined in the following subsections.

3.1. Diminishing research activities and students

With respect to the diminishing research activities and the related problem of less and less students in the nuclear field, the Federal Government has appointed the so-called Evaluation Committee, whose recommendations have led to the establishment of a so-called ‘Nuclear Technology Competency Pool (NTCP)’. The main objectives of the NTCP is to coordinate the publicly financed nuclear research activities of the main four nuclear research facilities in Germany and to provide research opportunities in the field of nuclear science and technology for qualified students.

3.2. Maintenance of expert knowledge at the regulatory body and technical support organizations

Currently there are basically four approaches to maintain the expert knowledge at the regulatory body and its technical support organizations, outlined in the following subsections.

3.2.1. Sponsoring of knowledge management activities

The Federal Government actively supports knowledge management activities at technical support organizations by government funded projects. For instance, within a project, the foundations for the subsequent knowledge management activities of GRS were developed, which are the subject of two other presentations in this workshop.

3.2.2. Sponsoring of courses covering selected topics in nuclear safety and technology at the regulator and technical support organizations

These courses are held on a regular basis and are funded through a special government programme. The topics are selected according to the short and mid-term requirements of the regulator or technical support organizations. In addition to government sponsored activities, the technical support organizations themselves have implemented their own educational programmes, such as the TÜV academy.

3.2.3. Implementation of advanced information management techniques at the regulatory body (RS-portal)

An important activity is to gather all relevant information sources required in order to perform the main tasks of the regulatory body into one web based portal. This portal, called the reactor safety (RS) portal, is currently under construction. It contains legal and technical information and databases, as well as information on generic safety issues (GESI).

3.2.4. Competence loss analysis

With respect to an increasing number of experts retiring in the next few years, the Federal Government has initiated a competence loss analysis. The general methodology is to: (1) identify the competency needed to perform the necessary regulatory functions in the next five to ten years; and (2) to develop recommendations on maintaining this competency on the basis of the projected development in staff numbers and competencies/experience (maintain competency by reassigning responsibilities, hiring new staff, etc.).

Step 1 is currently under way. Due to the complicated structure of the regulatory body this is a difficult undertaking. Some legal and organizational problems were encountered in the process, so that no definite results can be reported yet.

4. CONCLUSION

The complicated regulatory structure in Germany results in increasingly inefficient procedures. The Federal Government has initiated a study (Kienbaum Report), whose objective was to make recommendations with respect to a more efficient structure. In the current situation a more centralized structure is advantageous. However, moving from a Federal to a centralized structure requires comprehensive legislative action, and thus has to be seen on a larger timescale. Some of the activities mentioned (e.g. nuclear technology competency pool; intensified training; RS-portal, including GESI database) are addressed in greater detail in the presentation on the CD-ROM attached to these Proceedings.

KNOWLEDGE MANAGEMENT AND NETWORKING FOR ENHANCING NUCLEAR SAFETY

T. TANIGUCHI, L. LEDERMAN
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Vienna

Presented by L. Ulfkjaer

Abstract

Striving for innovative solutions to enhance the efficiency of programme delivery and a wider outreach of its nuclear safety activities, the IAEA has developed an Integrated Safety Approach as a platform for linking its safety related statutory functions and its many associated activities. The approach recognizes the vital importance of the effective management of the knowledge base and builds on the integration between the IAEA's Safety Standards and all aspects of the provision for their application, including peer reviews and technical meetings to share lessons learned. The IAEA is using knowledge management techniques to develop process flows, map safety knowledge and promote knowledge sharing. The first practical application was the establishment of a knowledge base related to safety aspects of ageing and the long term operation of nuclear power plants. The IAEA is also promoting and facilitating the establishment of regional nuclear and radiation safety networks to preserve existing knowledge and expertise, as well as to strengthen the sharing and creation of new knowledge in these fields. Prominent examples are the Asian Nuclear Safety Network established in the frame of the IAEA's Programme on the Safety of Nuclear Installations in South East Asia, Pacific and Far East Countries, and the Ibero-American Radiation Safety Network in the frame of the Ibero-American Forum of Nuclear Regulators. Results to date are most encouraging and suggest that this pioneering work should be extended to other regions and eventually to a global nuclear safety network. Responsive to the needs of Member States, the IAEA Secretariat has prepared and made available a large number of up to date training packages in nuclear, radiation, transport and waste safety, using IAEA Safety Standards as a basis. It is also providing instruction to trainers in Member States on the use of these modules. This ensures that the material is properly used and that the IAEA receives feedback so that training services and material are improved and kept current. This approach adds a new dimension to transferring knowledge as compared with conventional training methods. Recognizing that nuclear safety and security are truly global and transboundary issues, the IAEA has put forward the vision of a global nuclear safety and security regime that provides for the protection of people and the environment from effects of ionizing radiation, the minimization of the likelihood of accidents that could endanger life and property, and effective mitigation of the effects of any such events. The IAEA will pursue knowledge management and networking as fundamental elements for achieving this vision.

1. INTRODUCTION

The nuclear industry worldwide has a high safety record and has shown substantial improvement over the past decades. Nevertheless, in the light of accumulated nuclear power plant operational experience, the sharing of information on significant safety improvements, best practices and lessons learned remains a key opportunity to ensure that *a safety improvement anywhere is a safety improvement everywhere*. This will meet the safety needs related to long term operation of the current fleet of nuclear power plants and the design and construction of new ones.

For the IAEA, the challenge has been to enhance the effectiveness of the delivery and outreach of its nuclear safety activities within limited resources. Exploiting the rapid developments in information technology and the application of knowledge management tools, the IAEA has developed an ‘integrated safety approach’ (ISA) that establishes a linkage between the development and application of its Safety Standards, the associated feedback mechanisms and the strategic management of the comprehensive knowledge base created for this purpose.

To implement the ISA, the IAEA is, step by step, introducing process flows, identifying safety domains and mapping safety knowledge. A pilot project on safety knowledge management related to ageing and long term operation of nuclear power plants has been successfully implemented.

As an integral part of this approach, the IAEA is also promoting and facilitating the establishment of regional nuclear and radiation safety networks to preserve existing knowledge and expertise, and to strengthen sharing and creation of new knowledge. Thus, state of the art knowledge management and networking, when applied, reinforce each other.

Sustainable education and training is the key to safe utilization of nuclear energy and depends closely on the quality and usefulness of the knowledge base. Therefore, the IAEA is orienting its efforts to the development of standard training packages based on IAEA Safety Standards and training trainers at national and regional training centres.

2. INTEGRATED SAFETY APPROACH (ISA)

Establishing nuclear safety standards and providing for their application are main statutory functions of the IAEA in the area of nuclear safety. To ensure the effective linkage between these functions and related activities, the IAEA has developed an ISA. The ISA provides a platform for continuous improvement using the feedback from safety reviews, education and training;

technical cooperation projects, and coordinated research programmes. It also fosters information exchange through conventional means, such as conferences, workshops and technical meetings, and facilitates the establishment of regional safety networks.

Central to the ISA is the efficient management of the associated knowledge base. Therefore, the IAEA is pursuing a vigorous knowledge management programme to elicit and preserve existing knowledge, as well as to promote the creation of new knowledge.

Figure 1 depicts the ISA elements, including the feedback mechanism, the associated knowledge base and the networking to share safety knowledge among Member States.

The IAEA is using a similar approach for its nuclear security activities, but that is beyond the scope of this paper.

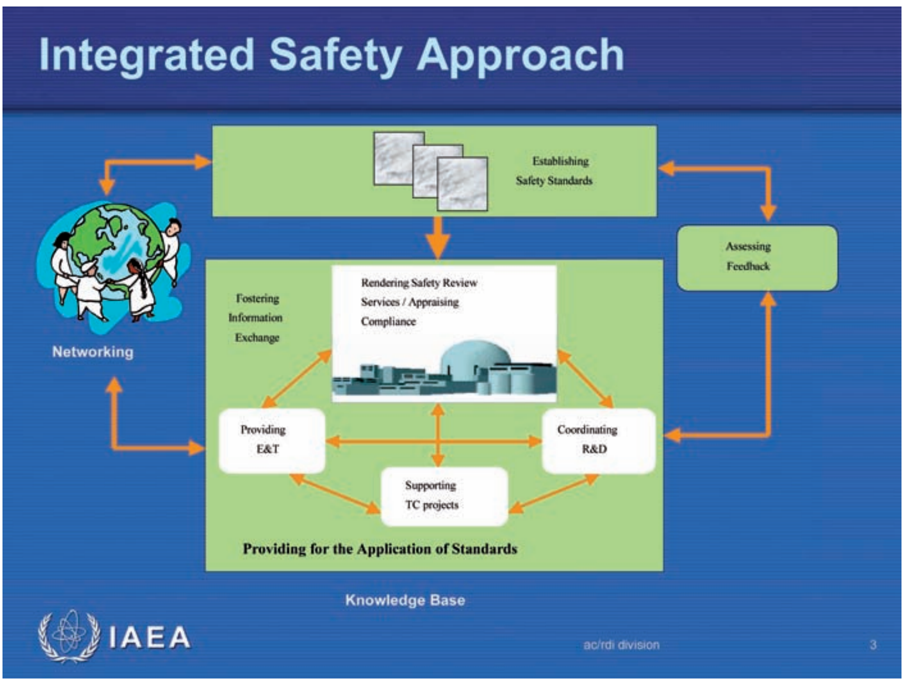

FIG. 1. Integrated safety approach.

3. PRACTICAL APPLICATION OF KNOWLEDGE MANAGEMENT METHODS

The IAEA's introduction of knowledge management methods into its nuclear safety programme is following a planned, step by step process. This process takes into account that the programme is primarily knowledge based and that nuclear safety knowledge, both thematic and process oriented, is an asset that needs to be elicited, classified, analysed, preserved and networked for easy retrieval and mutual learning. Considering the needs of the nuclear safety community in Member States, the process identifies and retains relevant knowledge associated with the preparation and application of the IAEA Safety Standards. This includes results of safety reviews, coordinated research programmes, and education and training activities. Implementation of the knowledge management system involves the following steps: the identification of knowledge domains and knowledge centres; the development of knowledge taxonomy for codification; knowledge mapping and retention; and the development of a portal for knowledge retrieval and sharing.

The underlying concept for the long term sustainability of the system provides for a decentralized yet interconnected operation with ownership and commitment from stakeholders at all levels, and cultivates an environment that values knowledge sharing and promotes its bottom-up application in both new and existing work routines.

A safety knowledge portal is designed for convenient access to existing and new knowledge related to the IAEA's nuclear, radiation, transport and waste safety activities. It includes thematic or subject related knowledge and process oriented knowledge.

Figure 2 depicts the basic structure being used for knowledge retention and retrieval. For each safety domain a knowledge base will be developed using a standard structure. The application of the structure to ageing and long term operation of nuclear power plants is described in the next section.

3.1. Safety knowledge based on ageing and long term operation (SKALTO)

SKALTO for nuclear power plants is the first IAEA practical application of knowledge management techniques related to its nuclear safety programme. This technical area was chosen in 2002 for a knowledge management pilot project because of the existence of a comprehensive guidance on effective management of the physical ageing of nuclear power plant systems, structures and components important to safety which the IAEA developed in the 1990s [1]; Refs [2] and [3] provided the core for SKALTO's knowledge inventory.

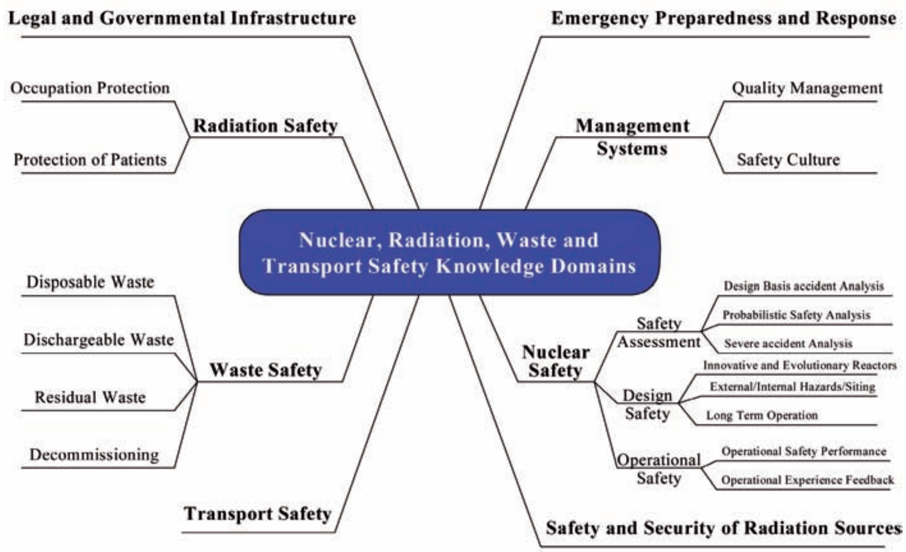

FIG. 2. Safety knowledge structure.

The objective of SKALTO is to develop a framework for sharing knowledge on safety aspects of ageing management and long term operation (LTO) of nuclear power plants in order to help: (a) IAEA Member States maintain high levels of nuclear power plant safety and performance through effective ageing management and other LTO programmes; and (b) IAEA staff increase the effectiveness of relevant activities. The scope of SKALTO is limited to the management of physical ageing of nuclear power plant structures, systems and components important to safety, and other LTO programmes, such as periodic safety review, configuration management and design basis data management.

The goal of SKALTO is to identify and store relevant knowledge (or provide links to relevant knowledge sites) to facilitate its retrieval, updating, extension and dissemination to potential users, and thus to promote more creative and effective ageing management and LTO programmes and activities. The key users include IAEA staff; nuclear power plant operating, regulatory, technical support, design and supplier organizations; and research institutes and universities.

The basic structure of SKALTO is shown in Fig. 3. It includes sections of IAEA Safety Standards relating to ageing management and LTO; programmatic and component-specific guidance on ageing management; national standards; results of ageing management and LTO safety reviews; lessons

FIG. 3. Basic SKALTO structure.

learned from operating experience; R&D results; as well as education and training materials.

SKALTO implementation is proceeding in phases to facilitate system testing, refinement and a gradual increase in the knowledge inventory. Phase I, implemented on the IAEA intranet in January 2004, was limited to using readily available IAEA nuclear safety programme materials. A limited scope version is available to the public at http://www-ns.iaea.org/projects/salto/default.htm.

In Phase II, the scope was increased to include additional IAEA material and improve ease of use. Phase III will include a full Internet version and links to relevant web pages of other organizations. Beyond Phase III, work will include a development of an interactive portal system to facilitate communication among practitioners aimed at problem resolution, and a continuous improvement of SKALTO's knowledge base and its retrievability. SKALTO has appropriate confidentiality and security measures built in.

More information on SKALTO, including a demonstration of the Phase II prototype, is available in the Poster Session part of the CD-ROM attached to the Proceedings.

3.2. Process flows

Work is also underway on the development of process flows for process visualization and the association of flow elements to knowledge domains. A particular application is related to the development of nuclear safety standards and other safety related publications. The development of IAEA Safety Standards is a complex process that involves specialized subject related knowledge and a large and diverse group of stakeholders in the review and approval process. Principal stakeholders are the IAEA and other technical experts drafting the standards, the specialized review Committees, the international scientific community represented in the review and comments of Member States, the Commission of Safety Standards that advises the Director General and, depending on the category of the Safety Standard, the IAEA Board of Governors.

Knowledge management tools for process modelling are being explored to increase the effectiveness and efficiency of the IAEA's Safety Standards development process. Each step of the flow is analysed with respect to the thematic and process knowledge involved. Knowledge intensive paths and tasks are identified, logical relationships among activities are displayed, and knowledge needed is elicited and associated to the knowledge domains.

Figure 4 is a much simplified presentation of basic elements and knowledge domains of the process flow for the development of IAEA Safety Standards.

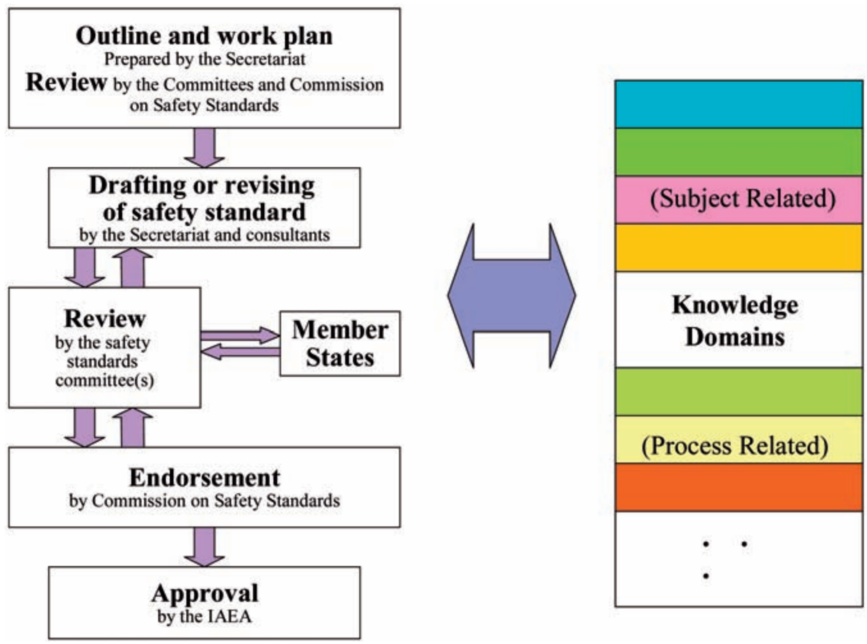

FIG. 4. Process flow for the development of IAEA Safety Standards.

4. NUCLEAR AND RADIATION SAFETY NETWORKS

Although there is a wealth of safety knowledge throughout the world, unless that knowledge is effectively compiled, analysed, shared and used by the scientific community, it will remain of limited value. Therefore, the IAEA is promoting and facilitating the establishment of regional nuclear and radiation safety networks to map, retain, share and create new knowledge in these fields. Prominent examples are the Asian Nuclear Safety Network, and the Ibero-American Radiation Safety Network.

4.1. Asian Nuclear Safety Network (ANSN)

The ANSN was established in the frame of the extrabudgetary programme on the safety of nuclear installations in South East Asian, Pacific and Far East Asian countries. It started operation in 2004 after completing in 2003, a pilot phase focused on education and training.

The network is operated in a coordinated yet decentralized manner with hubs in China, Germany, Japan and the Republic of Korea. Other countries participating in the ANSN are Indonesia, the Philippines, Malaysia, Thailand and Vietnam. In these countries, national centres are being established to host national knowledge and as portals to the ANSN. The establishment of national centres is also an essential step towards developing national networks for sharing safety knowledge among institutions and experts in each country. The IAEA is providing technical guidance and assistance to these initiatives.

The ANSN operation links web servers operating at the hubs and national centres with a master index hosted by the IAEA. This master index serves as a portal for users to interrogate and retrieve safety knowledge.

Taxonomy was developed for classification of technical knowledge related to nuclear power plants, research reactors and fuel cycle installations. Documents and associated metadata are stored and maintained at the local web servers operating at the hubs and national centres, and communicated to the master index database. The master index and the local databases are synchronized.

Users can search using the ANSN master index or the indices maintained at each hub. Documents are retrieved directly from the local servers where they are stored.

The ANSN shares thematic knowledge associated with the work of four topical groups dealing with, respectively, safety analysis, education and training, operational safety and safety culture. The ANSN is also a portal for access to the database maintained by the IAEA on results of the extrabudgetary programme. A group of information technology specialists from the IAEA and participating countries develops and implements the information technology solutions for the ANSN.

The ANSN is password protected and users may be granted different levels of access. A steering committee has been established by the IAEA to coordinate the development and operation of the network.

The ANSN structure is represented in Fig. 5. More information on the ANSN is provided in the Poster Session part of the CD-ROM attached to these Proceedings.

4.2. Ibero-American Radiation Safety Network

A web based radiation safety network is under development to capture and analyse existing and new nuclear and radiation safety knowledge and practical experience, and to disseminate it within Ibero-American countries.

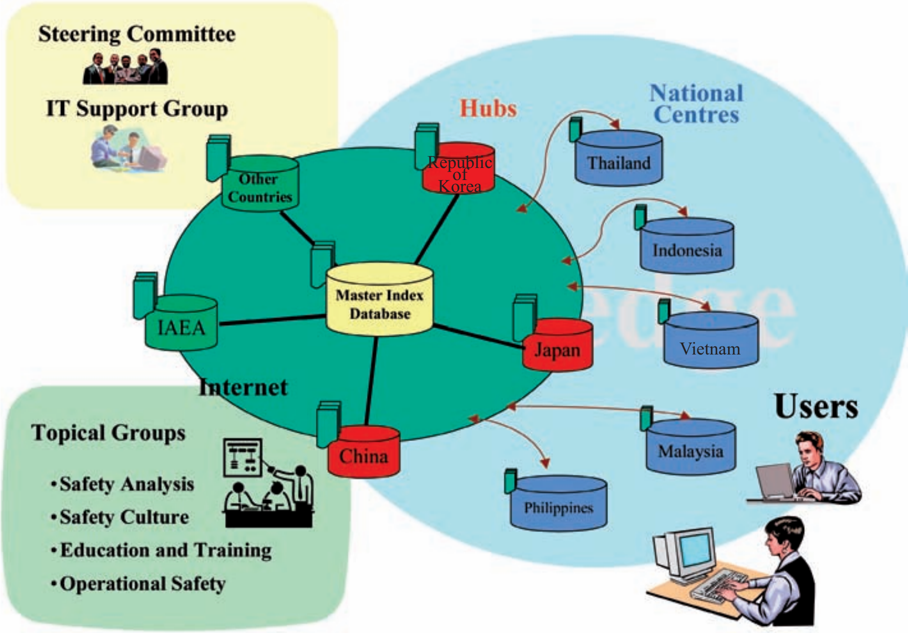

FIG. 5. Asian Nuclear Safety Network.

The IAEA started work in late 2003, under an extrabudgetary programme on nuclear and radiation safety in Ibero-America and in close cooperation with the Forum of Ibero-American Nuclear Regulators.

Experts from Argentina, Brazil, Chile, Cuba, Mexico and Spain have been engaged in the development of the network structure. The information technology structure for the network has been developed and the network functionality requirements have been specified.

A demonstration version of the network covering four areas — application of the Code of Conduct on the Safety and Security of Radioactive Sources, the radiological protection of patients, legal and regulatory infrastructures, and education and training — has been developed in Spain and successfully tested.

The operational concept of the network is similar to the ANSN. It includes a master index for knowledge search and retrieval of documents stored at servers located in the participating countries.

The network will facilitate on-line and off-line knowledge exchange among experts and promote a continuous and mutual learning process. It should be fully operational by the end of 2005.

5. NUCLEAR SAFETY EDUCATION AND TRAINING

The basic orientation of the IAEA's activities in this area is to support efforts in Member States to develop and to maintain up to date sustainable education and training programmes. The strategy adopted includes the preparation of standard training materials in nuclear, radiation, transport and waste safety using the IAEA Safety Standards as a basis; 'training the trainers' courses to ensure that the materials are used effectively; and utilization of feedback to update and improve the training materials. This approach is an effective means to enhance the transfer of knowledge as compared to conventional training methods.

An essential element of the strategy is the establishment of regional and national training centres that will ultimately be responsible for delivering training courses based on IAEA curricula and training materials.

The IAEA is preparing standard training packages for areas of need identified by Member States. Standard training packages assist training centres to organize courses on specific topics and help lecturers to prepare and deliver the courses. The packages contain guidance for organizing courses, viewgraphs with associated text and reference material. The challenge is to ensure and maintain the high quality of the technical and visual content of the training material.

Qualified trainers are essential for the sustainability of national education and training programmes. The IAEA provides assistance to prepare trainers both in subject and methodological matters as a means to ensure the multiplicative effect of education and training. This includes assistance to organize training courses based on the IAEA's standard syllabuses, preparation of exam questions, exercises and case studies for classroom discussion.

Distance learning modules are also being prepared and made available by the IAEA to Member States. A typical distance learning package consists of a modular set of course notes, study guides and associated exercises based on specific topics from a syllabus. Participants complete the package at their place of work or at home. This method of training is an effective use of resources and permits the participants to study at their own pace. However, the success of the training depends on the self-motivation of the student to complete the work with the minimum of direct supervision. The IAEA is using this approach to ensure a common entry level of technical knowledge as a prerequisite for some of its nuclear safety courses.

A network of training centres to share experiences and training materials is an essential element of the strategy. In this context, a network is an electronic database for the exchange of training materials, as well as a forum for the exchange of information through regular meetings of training experts. To achieve a sustainable system, the concept is to have decentralized storage of documents and materials. For the Asian region, this goal is being pursued by the ANSN.

6. LOOKING AHEAD

Recognizing that nuclear safety is truly global and transboundary, the IAEA has a vision of a global safety regime that protects people and the environment from the effects of ionizing radiation, minimizes the likelihood of accidents that could endanger life and property, and effectively mitigates the effects of any such events. To achieve this vision, the IAEA will continue to attach strategic importance to the development and application of knowledge management to integrate information from diverse sources into a comprehensive and user friendly knowledge base. With the practicality and usefulness of the knowledge management techniques demonstrated, the IAEA will be steadily expanding the knowledge base to cover all important thematic and facility related knowledge. This will enhance the use of available and new safety information by the professional nuclear community and to educate and train the workforce of tomorrow.

The ISA, embedding effective knowledge management and networking, will allow the IAEA to proactively identify new safety trends and effectively contribute to the establishment and maintenance of a global safety regime which will best serve the needs of its Member States.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the contributions of a former IAEA staff member, J. Pachner of Ottawa, Canada, who developed the initial SKALTO design and development plan and of T. Inagaki, of the IAEA's Engineering Safety Section within the Department of Nuclear Safety and Security, who has implemented the project.

REFERENCES

[1] PACHNER, J., International Atomic Energy Agency Programme on Managing Safety Aspects of Ageing Nuclear Plants, Kerntechnik 67/4, Karl Hanser Verlag, Munich (2002).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Guidance on Ageing Management for Nuclear Power Plants, Version 1, 2002, IAEA-GNPPA-CD/1, IAEA, Vienna (2002).
[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Periodic Safety Review of Nuclear Power Plants, IAEA Safety Standards No. NS-G-2.10, IAEA, Vienna (2003).

NUCLEAR KNOWLEDGE MANAGEMENT AT THE CANADIAN NUCLEAR SAFETY COMMISSION

B. DUFF
Directorate of Operational Strategies,
Canadian Nuclear Safety Commission,
Ottawa, Ontario, Canada

Abstract

The Canadian Nuclear Safety Commission (CNSC), like most other organizations in the nuclear industry, faces the challenge of capturing and managing its nuclear knowledge due to an ageing workforce. The CNSC is actively addressing this challenge in several ways, including ongoing development of its regulatory framework and regulatory documents; its research and support programme; through its human resources management and information, records and document management; and its management system. In addition to these internal activities, the CNSC also contributes externally to nuclear knowledge management. The paper presents an overview of these activities and identifies some of the broader lessons learned.

1. BACKGROUND

The Canadian Nuclear Safety Commission (CNSC) regulates the nuclear industry in Canada. The Nuclear Safety and Control Act provides the CNSC with its mandate which is to:

— Regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information in order to:
  - Prevent unreasonable risk to the environment and to the health and safety of persons associated with that development, production, possession or use;
  - Prevent unreasonable risk, to national security, associated with that development, production, possession and use;
  - Achieve conformity with measures of control and international obligations to which Canada has agreed;

— Disseminate objective, scientific, technical and regulatory information to the public concerning the activities of the Commission and the effects, on the environment and on the health and safety of persons, of the development, production, possession and use of nuclear energy, nuclear substances, prescribed equipment and prescribed information.

Nuclear knowledge management is not only important to the CNSC, but also necessary to fulfil our mandate. The CNSC regulates over 2500 licensees possessing over 4000 licences, including nuclear power reactors, research reactors, research facilities, uranium mines and mills, uranium fuel fabricators, hospitals, universities, cancer clinics, nuclear substance processing, industrial uses of nuclear substances, transportation, packaging and radioactive waste management facilities. The CNSC is one of the few nuclear regulators in the world which regulates all nuclear activities, from 'cradle to grave'. Due to the broad mandate of the CNSC, it is necessary to capture and manage a wide variety of nuclear knowledge.

2. REGULATORY FRAMEWORK

The CNSC operates within a legal framework that includes law and supporting regulatory documents. The law includes the Nuclear Safety and Control Act, regulations, licences and orders, which are the legal instruments. The regulatory documents include policies, standards and guides.

The CNSC is a performance based regulator which specifies the high level performance objectives through the legal instruments with some prescriptive requirements in a limited number of areas. The licensees remain responsible to achieve those performance objectives and have the flexibility to adopt alternative approaches subject to approval by the CNSC.

It is CNSC policy[1] to consult with stakeholders and to be open and transparent. During the consultation process, stakeholders and the public are provided the opportunity to comment on the regulations and regulatory documents. In responding to the comments received, CNSC subject matter experts must document the justifications, rationales and responses. Responding to comments received during these consultation activities provides an important mechanism for capturing our knowledge.

---

[1] CANADIAN NUCLEAR SAFETY COMMISSION, Regulatory Policy P-299 —Regulatory Fundamentals, April 2005.

3. REGULATORY DOCUMENTS PROGRAMME

The mandate of the division responsible for the regulatory documents programme is to manage the development of the requisite regulatory documents and to maintain those documents and related services. The purpose of the programme is to document the regulatory philosophies through regulatory policies, to specify lower level requirements in regulatory standards and to provide guidance on acceptable methods to achieve compliance with requirements through regulatory guides. The development of these documents is a key activity in capturing corporate knowledge.

Historically, the CNSC had difficulties producing regulatory documents. It was constantly seeking perfection, there was a bottom-up approach for identifying the needed documents, roles and responsibilities were not clear, and even prioritizing document needs proved to be problematic.

To overcome these issues, a 'regulatory document improvement initiative' was launched. CNSC top management was made the project authority for this initiative. Roles and responsibilities were clarified and documented. The processes and procedures were approved by the project authority and supporting tools, such as team charters to guide the document development teams in their work, were developed.

The 'regulatory document development process' is similar to that used by recognized standards development organizations. Drafting and review teams are made up of CNSC subject matter experts — capturing their knowledge and experience in the development of the documents. CNSC staff, licensees, stakeholders and the public are all provided opportunities to comment on the draft documents. As mentioned earlier, in responding to the comments received, corporate knowledge is also being captured.

By improving the regulatory document development process, the CNSC can better achieve its longer term vision for the regulatory documents programme. That vision is to have a comprehensive, cohesive hierarchy of documents that flow from the Nuclear Safety and Control Act and regulations to provide appropriate clarity and to afford a basis for regulatory expectations and decisions.

4. RESEARCH AND SUPPORT PROGRAMME

The CNSC has an active research and support programme to provide access to independent advice, expertise, experience and information outside of the organization. The mission of the programme is to generate knowledge and information to support the CNSC's regulatory work. Since the CNSC owns the intellectual property resulting from the research and support projects (documents, reports, data), this programme is another important mechanism for capturing needed knowledge, particularly when the CNSC does not possess that knowledge and expertise within.

5. HUMAN RESOURCES MANAGEMENT

In 2000, due to an ageing workforce at the CNSC and within the nuclear industry, the CNSC realized it needed to change its hiring practices. In Canada at that time, there was also the lack of university programmes in nuclear engineering and science. So to help rejuvenate its workforce, the CNSC initiated the internship programme, which is an entry level programme into the CNSC for university graduates.

Successful candidates were chosen from several Canadian universities. The criteria included scholastic achievement in science or engineering; previous work experience; personal suitability; good communications and interpersonal skills; and an interest in the CNSC's regulatory work. The criteria did not include experience or knowledge in the nuclear field.

Intensive training, mentoring and job shadowing were built into the programme for each intern. Training ranged from basic office skills to CANDU reactor fundamentals. To provide the necessary training, CNSC subject matter experts helped to develop the training courses. This process also enabled capturing their specialist knowledge. Mentoring and job shadowing were done only after interns and mentors were interviewed to ensure mutual compatibility. This helped to promote the transfer of specialist knowledge from our subject matter experts to the interns.

The internship programme was deemed a success by both the interns themselves and CNSC management. Out of the 20 interns recruited, to date only two interns have left the organization. It was recognized that even if the interns left for jobs elsewhere in the industry, the CNSC would still be contributing to a safe nuclear industry because of the excellent safety and regulatory knowledge they had received. An article on the internship programme written by one of the interns was published in the July 2004 issue of the Nuclear Engineering International magazine.

There were other positive spin-offs from the internship programme. An important spin-off was the development of the CNSC learning management system, which is an integrated planning tool for individual training needs for all staff. This system helps the CNSC manage the wide variety of training required for staff.

The use of CNSC subject matter experts for developing nuclear science and engineering courses to support the interns' training needs was an important way of capturing knowledge. This has proven to be a significant contribution to the knowledge management objectives of CNSC. These courses are available for all CNSC staff through the learning management system and are also available to anyone with Internet access through the Canteach web site at www.canteach.candu.org.

In addition to losing its technical staff, the CNSC faces an imminent shortage of top and middle management, who are also retiring. So the focus is shifting slightly to succession planning, manager development programmes and executive leadership training. The CNSC will, however, continue to use the best practices learned from the internship programme for knowledge transfer as we bring in new staff.

6. INFORMATION, RECORDS AND DOCUMENT MANAGEMENT

Managing the CNSC's information, records and documents, is another important part of knowledge management activities. Much of the recorded knowledge in CNSC is in the form of emails, letters, staff analysis reports on licensing submissions and licensing decisions rendered by the Commission. It is crucial for staff to be able to find and retrieve this information.

Since the CNSC is a Federal Government entity, it is bound by other Federal legislation, such as the Library and Archives of Canada Act, the Privacy Act and the Access to Information Act. There is a broad initiative by the Government of Canada under way to develop common business rules, practices and processes for information management. One of the tools developed for this is the Records, Document and Information Management System which is a single repository for integrated records and document management. This will help CNSC staff retrieve and transfer its information and knowledge.

7. MANAGEMENT SYSTEM

When properly implemented, a management system is recognized as a valuable tool to improve the efficiency and effectiveness of an organization. It encourages the identification, definition and control of processes, and provides a framework for continual improvement.

The CNSC management system is integrating and aligning all this knowledge and information with its management principles, practices and processes. The Management System defines and applies a common set of planning and management principles and practices (processes) across the organization to support the effective and efficient achievement of corporate objectives and stakeholder expectations. The CNSC management system and its documentation are consistent with the requirements for quality management systems identified in draft IAEA guidelines on management systems for regulatory bodies.

The documentation of the management system consists of high level descriptions, processes and supporting procedures, and the detailed working documents necessary to ensure that work is properly performed. At the top of the documentation hierarchy sits the Management System Manual. As the CNSC works towards populating it, it is capturing the knowledge needed to perform its regulatory work from the high level reference documents (policies, mandates, process maps) right down to the working level — procedures, work instructions (see Fig. 1).

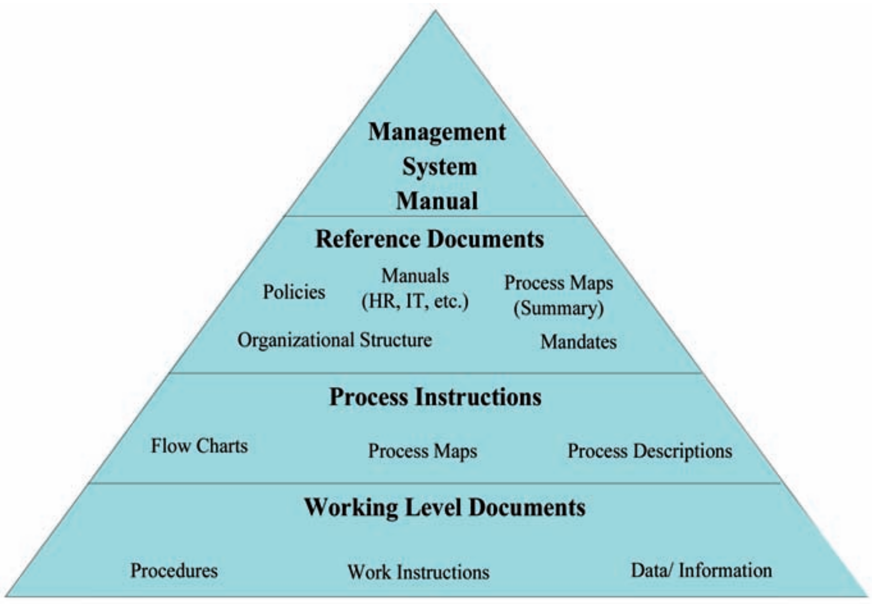

FIG. 1. Management system documentation hierarchy.

8. OTHER CONTRIBUTIONS TO NUCLEAR KNOWLEDGE MANAGEMENT

In addition to its internal programmes and initiatives, the CNSC also contributes to nuclear knowledge management activities outside the organization. It actively participates in the development of international standards, safety guides and technical documents by providing its subject matter experts to the IAEA technical committees. It is also looking to strengthen its relationship with the International Standards Organization. The Canadian Standards Association (CSA) is a recognized national standards development organization. The CNSC contributes both funding and expertise to the CSA for the development of national standards related to the nuclear industry. The CNSC in turn uses these IAEA and CSA documents in its regulatory work and is incorporating some of these documents into its regulatory framework.

The CNSC is also a member of the University Network of Excellence in Nuclear Engineering (UNENE), contributing funding and expertise to this non-profit corporation established by the Government of Canada. This is a unique industry–university alliance established to ensure that the Canadian nuclear industry would continue to have a dependable supply of highly qualified and skilled professionals. Industry assists the universities in developing relevant research programmes, attracting bright students, and educating and training them to pursue the safe and efficient use of nuclear technology.

9. CHALLENGES AND SOLUTIONS

Since this paper presents an overview of the CNSC activities in knowledge management, the specific challenges encountered in each of the areas are not discussed. In general, as with most organizations, resources are an issue and raise questions regarding their adequacy, balancing the different needs, and addressing changing priorities. There is also the issue of timeliness — capturing the knowledge before it is lost — and the next five to ten years is critical. Resistance to change is another challenge in many activities. The CNSC is also facing some emerging regulatory challenges, such as the ageing of Canada’s nuclear facilities — does industry refurbish, replace or decommission? New reactors and new reactor technology present their own specific challenges because of the need to have the appropriate knowledge to meet these challenges.

Some of the lessons learned for achieving success in knowledge management are:

— Support of the top and middle management is essential;
— Use of subject matter experts for developing training materials helps to capture their knowledge and experience;
— Use of subject matter experts for mentoring and job shadowing promotes the transfer of knowledge;
— Roles, responsibilities, accountabilities must be clearly stated and understood;
— Use people or groups who are passionate about your initiative for your pilot projects;
— Have patience — the implementation of new ideas and programmes takes time.

10. CONCLUSION

Nuclear knowledge management has many different elements. This overview of CNSC activities demonstrates how it is actively capturing and managing nuclear knowledge in many ways. Knowledge management is not only the right thing to do, but it is also necessary to fulfil the mandate of the organization. It is also important if CNSC is to achieve the vision of its President, L.J. Keen: “to be one of the best nuclear regulators in the world.”

ASIAN NUCLEAR SAFETY NETWORK

L. ULFKJAER
Programme and Policy Unit,
Department of Nuclear Safety and Security,
International Atomic Energy Agency,
Vienna

Abstract

The Asian Nuclear Safety Network (ANSN) is a regional network to facilitate sharing technical knowledge and practical experience to further improve the safety of nuclear installations in South-east Asian, Pacific and Far East countries. The network is operated in a coordinated yet decentralized manner. A few topical groups, composed of specialists from the participating countries, were created as forums for exchanging experiences and safety related information on particular topics agreed upon by the participating countries. The paper briefly describes objectives, functions and operational concepts of ANSN.

1. INTRODUCTION

The Asian Nuclear Safety Network (ANSN) is a regional network to facilitate pooling, analysing and sharing existing and new technical knowledge and practical experience, to further improve the safety of nuclear installations in South-east Asia, and countries in the Pacific and the Far East. The focus of the ANSN is on knowledge related to strengthening regulatory infrastructures and the safety of research reactors and nuclear power plants.

The network is operated in a coordinated yet decentralized manner with hubs in China, Japan and the Republic of Korea. Australia, France, Germany and the United States of America are also assisting ANSN development and sharing safety knowledge. National centres are being established in Indonesia, the Philippines, Malaysia, Thailand and Vietnam, to host knowledge and to serve as portals to the ANSN. The establishment of national centres is also an essential step towards developing national networks for sharing safety knowledge among institutions and experts in each country.

A steering committee has been created to ensure efficient and effective planning and implementation of ANSN activities. The ANSN Steering Committee is composed of one representative from each country participating in the extrabudgetary programme on the safety of nuclear installations in

South-east Asia, and countries in the Pacific and the Far East, as well as a representative from the IAEA.

2. TOPICAL GROUPS

The topical groups, composed of specialists from the participating countries, were created as forums for exchanging experiences and safety related information on particular topics agreed upon by the participating countries. Each topical group is led by a coordinator from one of the ANSN hubs. The participants in the topical groups assume the responsibilities to contribute to the development and implementation of the work plan of the groups, to attend on-line and off-line meetings, to contribute to the documentation of the results.

Currently, three topical groups have been established:

(1) *Safety analysis*: This group has been established to provide a forum for the exchange of information and documentation among specialists dealing with safety analysis of research reactors and to maintain and improve the knowledge acquired during the 2001–2002 workshops.
(2) *Education and training*: The purpose of this group is to provide a forum to develop education and training tools to comply with the ANSN objectives. Furthermore to provide a forum to discuss attractive and user friendly sites for education and training and self-study, and to upload existing education and training documents into ANSN.
(3) *Operational safety*: This is a forum both for operators and regulators to share operating experience and information for nuclear power plants on focused topics, such as root cause analysis techniques, systematic approach to training for personnel, external assessment and self-evaluation methodologies.

The establishment of three new topical groups has been decided:

(1) Safety management of research reactors;
(2) Safety Standards;
(3) Emergency preparedness.

To support the implementation of the ANSN, an Information Technology Support Group (ITSG) has been established. The role of the ITSG is to solve common information technology issues, to realize the expected functions of the ANSN with the latest information technologies and to provide the participating countries with the technical support necessary to establish hubs and national centres. The ITSG is composed of IT participants from hubs, national centres and the IAEA.

It is intended to use the ANSN as a communication and discussion tool for the extrabudgetary programme activities (from the preparation stage to implementation and feedback), as well as a means of knowledge sharing. Measures for further promoting the ANSN were discussed: the importance of involving decision makers, a wide distribution of the ANSN newsletter, linkage with other cooperation frameworks, such as the Forum for Nuclear Cooperation in Asia (FNCA), enrichment of the contents and improvement of user interfaces.

3. OPERATIONAL CONCEPTS OF ANSN

The main operational concepts of ANSN fall into four areas:

— Adding content to the local hub;
— Making the added content available to the entire network;
— Searching and retrieving content from any hub;
— Seamlessly providing access to all hubs (i.e. the web sites) in the network and the topical groups hosted by the hubs.

3.1. Adding content to a local hub

The first step for a hub in adding content to ANSN is a thorough analysis of the content. The content is organized into three hierarchical levels:

— Group (e.g. a training course);
— Document (e.g. a lecture);
— Item (the physical entity, e.g. a document).

Based on the analysis, each level is described by metadata, including three taxonomy classes for each ‘group’ and ‘document’. The metadata for the ‘item’ contain a hyperlink (URL), which points to the location on the hub’s web server where they are stored. The metadata are entered manually and stored in a database located at the hub.

3.2. Making the added content available to the entire network

Once the metadata have been entered into the local database of the hub, they need to be communicated to the Master Index Database — hosted by the

IAEA. In order to keep the Master Index synchronized with all hubs, a mechanism has been developed where the Master Index at regular intervals (configurable for each hub) is polling the hubs requesting to receive the latest content added by the hubs. When a hub receives the request from the Master Index, the local database is queried for the requested information. The information is then communicated to Master Index in the form of XML data. Upon receipt, to ensure an appropriate quality, the Master Index will verify that the hub has provided the required information and then store the metadata in the Master Index Database. The newly added content from the hub is now available to the entire ANSN community (Master Index can also, at any time, request the entire content from any hub — not only the latest added content).

3.3. Searching and retrieving content on the ANSN

Searching the content of the entire ANSN is normally done through the web site of the Master Index (hosted by the IAEA). It is possible to search on two levels: group (e.g. training courses) or document (e.g. lectures). For each level it is possible to search by selecting a combination of taxonomy and other criteria, such as country or by keyword. Through the search results the user can assess the relevance of the result by reading the metadata (which, for example, contain an abstract). By selecting a (physical) item from the search result list, the Master Index will send an encrypted request to the remote hub. The hub will decrypt the message and execute the request by returning the requested content directly to the user's computer — without having to authenticate the user. (In case of a very large content, e.g. a video, the user may choose to request the content from the remote hub by sending an email. The remote hub may then send a CD-ROM by ordinary mail.)

3.4. Providing access to all hubs and topical groups

The ANSN is available to a closed user group and thus each web site is only accessible by providing a username and password. The administration of user names and passwords is managed locally at each hub. However, the principle of ANSN is also to share the knowledge hosted by each hub and therefore a mutual trust relationship is necessary. Most hubs and the national centres have (or are envisioned to have) documents related to nuclear safety that only concerns their own country (e.g. that could be regulatory, legal, local procedures, Yellow Pages). This information, however, might also interest other countries. This is in particular true if the countries share the same language, which is the case for Indonesia and Malaysia. Normally a user will be registered at one hub (by completing an on-line request for access). At each ANSN web site (hubs and national centres) there normally are references to the other web sites in the network. By clicking on the link to another site, the user will automatically be allowed access to this site — without having to be authenticated again. Technically this is being implemented by transmitting the user's credentials (in encrypted form) to the other hub, which then allows the user access. It is planned to establish a system whereby a user who has access to a hub will automatically have access to the restricted topical group web forums, provided the individual is a member of that topical group.

MANAGEMENT OF NUCLEAR KNOWLEDGE AT THE SLOVAK NUCLEAR REGULATORY AUTHORITY

J. HUSARCEK
Nuclear Regulatory Authority of the Slovak Republic (UJD),
Bratislava, Slovakia

Abstract

The paper presents the approach of the Nuclear Regulatory Authority of the Slovak Republic to the management of nuclear knowledge, its experience and lessons learned. The objective is to move towards better fulfilment of the organization's duties, products and services. A brief description is provided of the system for managing knowledge; sharing knowledge with partners; monitoring knowledge and its compliance with strategies and needs; access of employees and stakeholders to the relevant information; correctness, reliability and security of information; stimulation of information exchange; effective processing and use of information; presenting information in a user friendly manner; and retaining knowledge.

1. BACKGROUND

Knowledge is the key resource of most organizations in the world. It is generally made up from two main components — technical information or data and tacit knowledge or specialist skills. It is necessary to establish an appropriate knowledge management system within the organization for the purpose of knowledge identification, acquisition and development; dissemination and use; and preservation and process evaluation. It consists of a combination of records, standards, design and human knowledge capital. It is a part of the quality management system and should be subjected to regular self-assessment. The approach of the Nuclear Regulatory Authority of the Slovak Republic (UJD) to the management of nuclear knowledge to move towards better fulfilment of the organization's duties, products and services is briefly described in the following paragraphs.

2. SYSTEMS FOR MANAGING, PRESERVING AND EVALUATING KNOWLEDGE AND INFORMATION

The UJD expends significant effort and resources on the management, preservation and evaluation of knowledge and information. Its policy is based on the strategy issued by the State Service Office, suitably adapted to the UJD specific conditions through internal directives. The system is implemented on the basis of the Chairman's orders consistent with the plans and decisions of the Board of the UJD. It is regularly evaluated and improved to appropriately address external and internal environmental conditions.

The personnel information system contains data on UJD employees regarding previous professional experience, educational qualifications, training, technical visits, examinations passed, etc. The newcomers are initially appointed for a probationary period. After a satisfactory completion of the probationary period, completion of training and passing a qualifying examination, the newcomers are appointed to the permanent State service. Similarly, the position of UJD inspector requires systematic training completed by passing a qualifying examination. The system of training and continuous education is implemented, reflecting the current and future needs of the UJD. For this purpose, training facilities of the utility, partner organizations, technical support organizations, universities (for specific lectures), the IAEA and commercial organizations are used.

A significant source of information managed and preserved at the UJD consists of the decrees and guidelines; technical reports prepared by UJD staff or within the international cooperative programmes (e.g. Phare, Transition facilities); IAEA documents; outputs of research and development activities; travel reports and minutes of meetings; and databases with technical data of supervised nuclear facilities. The information is stored on paper and/or electronic form.

3. SHARING KNOWLEDGE AND INFORMATION WITH PARTNERS

Sharing knowledge and information with partners (stakeholders) represents an important tool for preserving and maintaining the knowledge base of the UJD. Information and knowledge exchanged with partners include benchmarking, harmonization and mutual learning from the best practices. The plans are prepared for medium or short term time periods. They are implemented in different ways. The UJD Chancellery and the Public Information Centre monitor the media, prepare and spread the gained technical information to UJD staff through the intranet. Important information, including legislative documents and decisions, are published on the Internet and in case of controversy, each UJD employee has access to the Internet and the technical information databases of the IAEA, OECD/NEA, and important partner organizations, such as the Nuclear Regulatory Commission (United States of America), STUK (Finland) and SUJB (Czech Republic). There are signs at workplaces to inform UJD staff. Employees of the UJD take part in training courses, technical visits, meetings, workshops and conferences of the IAEA and the OECD/NEA. The system for sharing knowledge and information is periodically evaluated. The measures identified for improvement are submitted for approval to the Board of the UJD.

4. CONTINUOUS MONITORING OF THE KNOWLEDGE BASE

The UJD continuously monitors the available knowledge and information within the organization, and maintains and develops the knowledge and skills to meet its current and future needs. Training and the continuing education of staff is arranged in a systematic and planned manner. The plans are developed on the basis of staff requirements and tasks to be performed, and are approved by the Board of the UJD.

5. ACCESS OF EMPLOYEES AND STAKEHOLDERS TO KNOWLEDGE AND INFORMATION

Access of employees to knowledge and information relevant to their tasks is a legal requirement. The access of staff to knowledge and information is ensured through permanent access to the Internet/intranet and databases around the world; participation in conferences, workshops and meetings; networks of excellence; purchase of technical literature and textbooks; visits to partner organizations; and participation in review missions and international technical projects. UJD employees take an active part in knowledge management and provide feedback for improving the system on a continuous basis.

The most important tool for sharing information with stakeholders is the Internet. The UJD publishes all relevant information on its web site to the maximum extent possible, exceeding the legal requirements on public information. Some information processed and available at the UJD is proprietary or could be misinterpreted and therefore cannot be published, which creates potential conflicts with non-governmental organizations or the general public.

Important sources of information to the stakeholders are periodical and non-periodical publications, such as UJD decrees, guidelines, journals, bulletins or technical contributions of UJD staff to other periodicals. A questionnaire is used to get feedback from stakeholders on the scope, quality and access to information and its transparency. The UJD defines a set of responsibilities for reliability, correctness, security and updating of information provided on the web site (Internet/intranet). The UJD uses suggestions, recommendations and comments from stakeholders for the improvement of the web site and quality of shared information.

6. STIMULATION OF INFORMATION EXCHANGE

Internal channels for information exchange and cooperation between the departments and sections and among the staff are specified in the organizational set-up of the UJD. Information exchange and cooperation between the UJD and partner organizations is based also on international agreements or commitments approved at the governmental level. In addition, short term and medium term commercial agreements are in use to purchase or prepare the information or data for the UJD (e.g. research and development projects). The stimulation of information is evaluated and modified on the basis of interests of involved parties and their needs.

7. EFFECTIVE PROCESSING AND USE OF INFORMATION

External information gained or delivered to the UJD is directed, based on its content, to the responsible employee for processing or use. Processing information gained through the Internet is individual and depends on its nature and importance for each employee. The effectiveness of information processing and transfer is evaluated implicitly through the quality of services and products provided by the UJD, as well as feedback from UJD staff.

8. PRESENTING INFORMATION IN A USER FRIENDLY MANNER

The UJD has an interest in presenting all information in a user friendly manner. The web site (Internet/intranet), databases and presentations in written or verbal forms are used for this purpose. Satisfaction with the method of presenting information is evaluated by a questionnaire and its results are used for carrying out improvements.

9. RETAINING KNOWLEDGE AND INFORMATION

In compliance with an internal order of the UJD, each employee who is leaving has to pass all relevant information, data and documents to his or her designated counterpart or superior. The information thus passed on is evaluated. Exit interviews of leaving employees are common. The results are used in the improvement of the functioning of the UJD. Another method utilized in the UJD for retaining knowledge and information is to create a redundancy in the jobs of employees to be retired.

KNOWLEDGE MANAGEMENT WITHIN THE NATIONAL COMMISSION FOR NUCLEAR ACTIVITIES CONTROL AND RELATED SUPPORT PROVIDED BY INTERNATIONAL COOPERATION

F. IVAN
Division of International Affairs,
National Commission for Nuclear Activities Control,
Bucharest, Romania

Abstract

The National Commission for Nuclear Activities Control (CNCAN) is the Romanian competent authority in the nuclear field having responsibilities for regulation, licensing and control. CNCAN is in the process of recruiting new staff. In order to fill the vacancies, CNCAN will organize additional examination sessions in accordance with the commitments assumed within the Plan of Priority Measures for European Accession January–December 2005. The process for recruitment and staff training is developed in accordance with CNCAN internal rules approved by the Government. Taking into account priorities and opportunities, training is developed through self-study, as well as under the in-house training programme and/or under the international cooperation programmes. In this respect, CNCAN benefited from technical assistance from the IAEA and European Commission, as well as under bilateral cooperation with institutions from other countries developing activities in the field. CNCAN has already taken some steps towards introducing knowledge management. A knowledge preservation policy is in place, based on several measures including unlimited access to information provided through the Internet/intranet, access to dedicated publications, annual training programmes addressing the needs of the employees and the organization, knowledge dissemination sessions and increasing staff motivation.

1. INTRODUCTION

The National Commission for Nuclear Activities Control (CNCAN) is the Romanian competent authority in the nuclear field having responsibilities for the regulation, licensing and control of nuclear activities in accordance with the legal provisions. CNCAN is led by a President having the rank of State Secretary and is financed from its own resources (tariffs from licensing and control of nuclear activities). CNCAN's organizational chart contains 171 positions (including county resident staff), of which 49 are vacant. CNCAN is in the process of recruiting new staff and several examination sessions are already being conducted. In order to fill the vacancies, CNCAN will organize additional examination sessions in accordance with the commitments in the Plan of Priority Measures for European Accession January–December 2005.

2. KNOWLEDGE MANAGEMENT DEVELOPMENT

The regulatory body is facing two issues: (1) attaining the staff strength necessary for discharging the main functions related to the national priorities in the nuclear field; and (2) the necessity of maintaining the knowledge of its staff at a high level. National priorities in the nuclear field include the commissioning of Cernavoda nuclear power plant Unit 2; the start of construction activities for Cernavoda nuclear power plant Unit 3; the repatriation of spent fuel from the WWER research reactor from Bucharest-Magurele; decommissioning of WWER research reactor from Bucharest-Magurele; siting of the LILW repository for Cernavoda nuclear power plant, regulatory assessment of PSA study for LILW repository from Baita Bihor. In the context of a decreasing number of experts due to the retirement of experienced staff, and the long periods of time required for the professional education of young graduates, knowledge management is a laborious and continuous process.

3. HUMAN RESOURCE MANAGEMENT

In order to deal with these aspects, special attention is being paid to the personnel recruitment process. The selection and recruitment of personnel, as well as staff training are developed in accordance with CNCAN internal rules approved by the Government, with the provisions of CNCAN Collective Labour Contract, as well as with specific requirements for each of the approved posts, such as educational qualifications, special skills and previous work experience.

The recruitment process starts with announcements in designated newspapers and on the CNCAN web site. Promotional activities are also undertaken at designated universities and CNCAN participates in the job market. The applicant has to fulfil some general requirements, such as initial education, medical and psychological certification and statement of confidentiality, as well as some specific requirements related to professional background, experience in the nuclear field and specific personal skills.

The selection process consists of an evaluation of the candidates' applications and examination sessions (written and oral examinations and interviews). After the candidates are selected, some actions are undertaken for their integration in the organization, including the following: the candidate is assigned to the appropriate post; a supervisor is allocated; a period of probation is indicated (one month for new employees and six months for beginners); the candidate is asked to present a paper (only in the case of newcomers) after the probation period; and the paper, as well as the performance during the probation period, are assessed by a special Commission nominated by the CNCAN President.

4. TRAINING OF PERSONNEL

In accordance with the CNCAN Internal Procedure for the Identification of the Training Needs and Planning of Training Activities, an assessment of the training needs of new employees and experienced staff is carried out. The CNCAN Procedure follows the principles contained in the IAEA publications on systematic approach to training (SAT).[1] Heads of the technical and/or support divisions within CNCAN complete a questionnaire for the assessment of knowledge required by each post and submit it to CNCAN President for approval. Once a year or when hiring new staff, Heads of the technical and/or support divisions are required to complete a questionnaire for the assessment of knowledge of their subordinates. The employees are also subjected to an annual interview conducted by the Heads of divisions of CNCAN. Based on the results of the questionnaires and the short and medium term priorities of CNCAN, a training programme covering both short and medium terms (one year and five years, respectively) is established. Training results are included in the next questionnaire for the assessment of staff knowledge. Comparing two consecutive questionnaires would indicate the progress made during the year and the individual training programme could be annually adjusted.

The main objective of training is the development of specific skills and level of knowledge needed to perform specific regulatory tasks. Training should also ensure that the employees are aware of technological developments and new safety principles and concepts. Taking into account the priorities and opportunities, training is developed through self-study, as well as under the in-house training programme and/or under the international cooperation

[1] INTERNATIONAL ATOMIC ENERGY AGENCY, IAEA Guidebook on Nuclear Power Plant Personnel Training and Its Evaluation, Technical Reports Series No. 380, IAEA, Vienna (1996); INTERNATIONAL ATOMIC ENERGY AGENCY, Experience in the Use of Systematic Approach to Training (SAT) for Nuclear Power Plant Personnel, IAEA-TECDOC-1057, IAEA, Vienna (1998).

programmes. Self-study is used for ‘filling in the gaps’ with ‘tools’, such as writing documents, preparing electronic documents, exchange of information with experienced staff, use of the intranet and use of the Internet. The in-house training programme includes lectures performed by experienced CNCAN staff, on the job training and financial support for participating in dedicated training activities outside the organization.

5. INTERNATIONAL COOPERATION

International cooperation represents an important way of acquiring and maintaining knowledge at the highest standards. In the framework of international cooperation, young graduates have the opportunity of becoming acquainted with the best practices in the field and experienced staff would be able to exchange experience and update their knowledge. Over the years, CNCAN benefited from the technical assistance provided by the IAEA, the European Commission, the Center for Nuclear Safety and, with some institutions, developing activities in the field through bilateral cooperation (Canadian Nuclear Safety Commission, United States Department of Energy, United Kingdom Department of Trade and Industry, etc.).

Cooperation with the IAEA is in the main areas of technical assistance identified within the Country Programme Framework. According to this document, during 1993–2002, 37% of assistance was related to the nuclear safety field. The IAEA assisted Romania in establishing adequate infrastructure for licensing and enhancing national capabilities for safety assessment. CNCAN’s personnel benefited through training under IAEA fellowships and scientific visits. In addition, CNCAN staff also availed themselves of the opportunities offered by the IAEA Regional Programme in several fields, including safety and maintainability of nuclear fuels, quality assurance, ageing of nuclear power plant components, safety analyses at research reactors, regulatory control, nuclear safety, safety of radioactive waste management, radiation safety, occupational radiation protection, and decommissioning of nuclear facilities.

Romania established 2007 as the target for its accession to the European Union. The Report on Nuclear Safety in the Context of Enlargement (CONFRO 28/01) recommended that “CNCAN still needs training support for the newcomers…and for updating the knowledge of the existing personnel”. In view of this, international cooperation will continue to play an important role in the training of CNCAN personnel and represents the best way for enhancing and maintaining adequate knowledge in the field of regulatory activities, as well as ensuring the implementation of the best international practices.

6. CONCLUSION

In conclusion it may be stated that CNCAN has already taken a few steps towards implementing knowledge management within its organization. A detailed record of the training and knowledge base of the employees is kept by the Human Resources Section of CNCAN. A knowledge preservation policy has also been put in place. The employees have access to information provided by the Internet/intranet, dedicated publications (by subscription or direct procurement), participation in annual training programmes and knowledge dissemination sessions. Other measures include improving staff motivation through financial and professional incentives; more appropriate distribution of personnel; dedicated training plans for each division and each personnel category (beginners, advanced, experienced); development of computer based training for distance learning and addressing employees' career aspirations.

KNOWLEDGE MANAGEMENT AT IGNALINA NUCLEAR POWER PLANT

L. ALEJEVA
ITECA UAB,
Lithuanian Nuclear Power Safety Inspectorate (VATESI),
Vilnius, Lithuania

Abstract

The loss of information at any stage of a nuclear power plant life cycle, including decommissioning and the ultimate disposal of radioactive waste would result in the denial, to future generations, of knowledge that could be important to the safe and economic completion of work on the remaining part of the nuclear power plant life cycle, and to assist in the analysis of problems and options. There is a need to implement a methodology at an early stage in the nuclear power plant life cycle to capture corporate knowledge about nuclear power plant planning and implementation, as well as the tacit knowledge residing in the employees on all aspects of the project. The paper briefly describes the measures being implemented at Ignalina nuclear power plant with regard to knowledge management.

1. KNOWLEDGE MANAGEMENT AT IGNALINA NUCLEAR POWER PLANT

In Lithuania, elements associated with knowledge management were implemented at Ignalina nuclear power plant Units 1 and 2 during the early commissioning phases and nuclear knowledge is actively being captured and managed in many ways. The three main elements of the nuclear knowledge management strategy at Ignalina nuclear power plant are briefly described below.

1.1. Human resources management

Adequate staff strength needed for the safe and economic operation of the nuclear power plant is ensured through human resources management. The required levels of knowledge, skills and competency of the staff are ensured through the system of training and education.

Types of training used at Ignalina nuclear power plant include:

- Self-education;
- Mentoring;
- On the job training;
- Internal classroom training;
- Simulator training;
- Participation in the training courses organized by the plant for its staff;
- Participation in external training courses and conferences;
- Participation in forums for exchange of experience (international cooperation).

1.2. Capturing and preserving existing knowledge

The measures being implemented to capture and preserve existing knowledge include:

- Obtaining documentation from all available sources;
- Storing current RBMK knowledge on RBMK reactors (graphite moderated light water cooled pressure tube reactors) in document management database;
- Categorization and cross-referencing of records and documents;
- Facilitating retrieval of documentation through a dedicated web server: use of ARKI, a computerized system of technical documentation control that provides access to all documentation from any working area equipped with a network PC.

1.3. Sharing and pooling knowledge through the information management system

Since 1996, the FOBOS system (a set of modules of the computer software package Industrial Finance System) is being implemented for improving plant maintenance activities. Under the FOBOS system, a set of modules of the Industrial Finance System (IFS), software of firm IFS (Sweden) application system, similar to the concept of Enterprise Asset Management (EAM), have been developed.

The objectives of the FOBOS system are:

- Creating conditions to improve the quality of maintenance of the equipment and systems important to safety (RMMS);
- Implementing the Configuration Management System (CMS);

— Managing the warehouse inventory;
— Managing purchases.

Now this database serves as a practical tool for the preservation of knowledge about plant-specific equipment (date of installation, maintenance, qualification, modifications and others).

The scope of the FOBOS system includes:

— List of Ignalina nuclear power plant equipment;
— Work orders;
— Records management;
— Requests for repair;
— Documentation control;
— Work planning;
— Registration of parameters;
— Module on 'equipment ageing management' system integration of the processes of maintenance and repair (repair certificate, checklist, work permit, request, planning, reporting);
— Module on 'environment qualification'.

The equipment qualification database is another practical tool for the preservation of knowledge about the status of qualification of equipment. This database describes the qualification status on selected component identification (ID) level. The resulting qualification status is unique for each component ID location in the plant. The information in this database comprises all relevant interfacing components in the functional chain for each of the frontline pieces of equipment. The photographs or diagrams can be enlarged by a double-click on the picture.

The equipment qualification database contains the following information:

— Manufacturer;
— Type designation;
— Equipment;
— ID description;
— Room number;
— Normal operating temperature;
— Design basis event (DBE) time properties;
— DBE function properties;
— Accumulated dose at DBE;
— Temperature at DBE;
— All related equipment IDs;

— Qualification status.

The equipment qualification database displays six entry points:

— View by room;
— View by apparatus;
— View by component/environment;
— View by component;
— Search apparatus — view by component/environment;
— View qualification reports.

Existing databases allow generating, capturing, managing, sharing and utilizing the information, which are paramount in the construction, operation and maintenance of Ignalina nuclear power plant. The databases ensure that there is no loss of specific information at any stage of the nuclear power plant operation and provide the knowledge base, which could be important for the safe and economic completion of work, as well as for analyses of problems and options.

NUCLEAR KNOWLEDGE MANAGEMENT IN THAILAND

K. TIYAPUN
Office of Atoms for Peace,
Bangkok, Thailand

Abstract

Energy from fossil fuels is reaching its limits. The prospective technologies for long term supply of the world economy with energy on a sustainable basis are varied, with widely differing promises and problems. In recent years, advocates from the Government of Thailand have promoted the use of renewable sources (such as biomass or hydropower) and inexhaustible resources (such as solar energy and wind power) as the solution to the oil crisis problem. In addition, the continued and increasing use of fossil fuels is causing the problem of carbon dioxide emission and its potential impact on the climate. In the absence of public policies that promote renewable energy, Thailand is viewing nuclear energy as an alternative source for tomorrow's energy requirements. In order to play a significant role along with other energy sources, nuclear technology must be recognized by the public as a mature and safe technology. Nuclear knowledge management together with promotional policies from both the government and private sector will determine the possibility of nuclear energy becoming an alternative source for Thailand. Nuclear knowledge management is being carried out at several institutes in Thailand, including Chlalongkorn University, Kasetsart University, Office of Atoms for Peace (OAP), Department of Alternative Energy Development and Efficiency (AEDE) and Electricity Generating Authority of Thailand (EGAT). At present, most of the support regarding nuclear knowledge management in Thailand is coming from the IAEA, European Union member States, the Republic of Korea, India, China, the Russian Federation and Japan. Current measures to raise the awareness of the public on nuclear issues include cooperation between the universities and dissemination of information from sources, such as the IAEA International Nuclear Information System, and the Asian Nuclear Safety Network (ANSN).

1. INTRODUCTION

It was the fifth consecutive year that the annual energy consumption of Thailand had increased [1]. The demand for electricity continued to increase and the drive for sustainable development requires energy sources with limited environmental impact to achieve the Kyoto Protocol commitments. The current situation in Thailand provides an opportunity to re-evaluate the nuclear power option. At the public and policy levels, the concerns are related to nuclear safety and radioactive waste disposal. Supporting organizations such as the IAEA are assisting Thailand through technology transfer with regard to nuclear knowledge and in performing the necessary research and development activities. In parallel, Thailand has developed its own competence in contributing to nuclear technology transfer.

For nuclear power to play a significant role in Thailand, research and development capabilities and an adequate level of qualified human resources are essential. In this regard, Thailand has given priority to human resource development. Nuclear sciences and technology have been taught for several years in both the universities mentioned above. However, the popularity of this subject has decreased over the last 20 years and consequently the availability of experts and professionals in the field of nuclear power has declined. Although training in nuclear subjects has been provided to the employees of nuclear related organizations in Thailand, such as the Office of Atoms for Peace (OAP) and the Electricity Generating Authority of Thailand (EGAT), the retirement of nuclear experts and the lack of a nuclear power programme are posing serious problems in maintaining nuclear knowledge in the country.

The introduction of innovative, small and medium sized reactors to produce electricity in Thailand is a future possibility. To promote the development of nuclear technology, OAP had decided to construct a new research reactor since the 1990s. The Ongkharak Nuclear Research Center with a 10 MW TRIGA reactor was designed for multiple purposes, including isotope production, experimental research and development, and reactor safety research. The project is still pending because of organizational problems, inadequate investment, and a lack of public acceptance. During the last decade, several measures to solve these problems were undertaken. The dissemination of information to the public on the environmental impact of nuclear reactors, especially the research reactor, was considered as a major step. Therefore OAP has encouraged a public participation process by which the public and stakeholders can meaningfully participate in the new research reactor project at Ongkharak. The public was involved in an environmental monitoring programme which aimed to prevent and control adverse environmental impacts. The new research reactor project in Thailand strives for a fair share of beneficial outcomes from the project through community development and quality of life improvement in a sustainable manner.

2. NUCLEAR KNOWLEDGE SYSTEM

The structure of nuclear knowledge management in Thailand is illustrated in Fig. 1. In order to support the nuclear energy programme, several institutes and facilities provide education and training to develop human resources and produce adequate numbers of qualified personnel in the nuclear field. Figure 1 shows the institutes and facilities available to graduate students for research and development, professional training for working in nuclear research and power reactors, and dissemination of information to the public.

3. NUCLEAR EDUCATION AND COMPUTER NETWORK

The Department of Nuclear Technology in Chulalongkorn University was established in 1975 with the main purpose of training students planning a career in radioisotope applications and nuclear energy. The Department offers programmes leading to degrees, including Doctor of Engineering (D.Eng.), Master of Engineering (M.Eng.), Master of Science (M.S.) and Graduate Diploma in Nuclear Technology. The curriculum is established to cover diversified principles of nuclear technology ranging from fundamental science and mathematics to specialized engineering applications [2]. Areas of specialization include nuclear power engineering, industrial applications of radioisotope, nuclear instrumentation, radioisotope production, radiation processing, environment and safety, and nuclear materials. Since the inception of the Department, more than 200 M.Eng degrees were awarded. Most of the graduates entered government institutions, such as the Office of Atomic Energy for Peace (OAEP), Electricity Generating Authority of Thailand

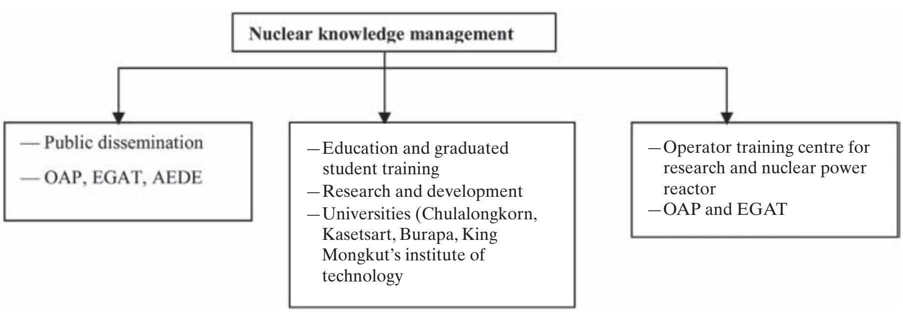

FIG. 1. Structure of nuclear knowledge management in Thailand.

(EGAT), and public and private universities partly in the area of medical sciences [3].

The aim of the university is to broaden and strengthen technical and research competency to ensure that nuclear technology is exchanged in the international area. Therefore an elaborate collaborative programme in human resource development has been established between the Canadian International Development Agency (CIDA) and Chulalongkorn University. This programme aims to upgrade the current academics with training in nuclear energy and to develop an adequate supply of new technical personnel for academics, the industrial sector, utility partners and the Government. Several Canadian and Thai institutes participated in this linkage project, including the Atomic Energy of Canada Limited (AECL); the University of Toronto; McMaster University; École Polytechnique Montréal; the University of New Brunswick; EGAT; OAEP; Prince of Songkhla University; Khon Kaen University; and the Federation of Thai industries. Currently, the Department consists of 11 faculty members, 1 AECL professor and 54 graduate students [2, 3].

In addition to the CIDA programme, Chulalongkorn University has an Association of Southeast Asian Nations (ASEAN) studies programme to strengthen regional solidarity and identity in nuclear engineering programmes in the Member States of ASEAN. ASEAN members include Brunei Darussalam, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. The ASEAN studies programme includes various activities, such as workshops, research collaboration, networking of ASEAN studies, curriculum and course development, and the establishment of an ASEAN studies centre in one of the member States of ASEAN [3]. One of the major objectives of the ASEAN University Network (AUN) is the promotion of cooperation and solidarity among scientists and scholars in the member States of ASEAN. This strategy is implemented through the exchange of students and scholars among key member universities from ASEAN member States [3]. Furthermore, the AUN provides scholarships and fellowships to trainees in science and technology, environmental sciences and engineering. It also established a management system to promote the educational and training schemes in the Member States. These are considered to be valuable resources and assets for the national and regional economy.

The AUN also provides for information networking among the universities in ASEAN member States. The programme emphasizes the establishment and development of an on-line information exchange system in the member universities. The programme implementation consists of two phases: (1) reviewing the inventory of existing information on the homepages of member universities, and (2) developing a virtual university through the development of courseware, initially on ASEAN studies, which could be developed into a degree programme [4]. The AUN has long been encouraging the use of information and communication technology (ICT) in education through the information networking programme. The launch of the AUN homepage [5] and the successful organization of a seminar on Information Networking and IT Development in March 2000, have enhanced the dissemination of information among AUN members [5].

4. COLLABORATION IN NUCLEAR RESEARCH

Collaborative research is one of the most effective knowledge management strategies. The principal aim of this programme is to enable ASEAN member universities with widely varying nuclear experience to be associated with the generation of knowledge and sharing of expertise and technology necessary for strengthening ASEAN universities and helping member States to develop greater technological self-sufficiency. Nuclear technology transfer from European Union member States to Thailand can be initiated by the ASEAN-EU University Network Program (AUNP). It is a joint initiative by the European Union and the AUN, aiming to improve mutual understanding between institutes of higher education in the 15 European Union Member States and nine ASEAN countries that are signatories to the EC-ASEAN Co-operation Agreement, as well as to promote regional integration within ASEAN countries. The projects involve applied research, human resource development and curriculum development. In the period 1999–2003, Republic of Korea–ASEAN, Japan–ASEAN, India–ASEAN, China–ASEAN and the Russian Federation–ASEAN academic exchange programmes were launched as collaborative programmes of Thai universities with those of the Republic of Korea, Japan, India, China and the Russian Federation [3]. These exchange programmes provide academic opportunities for mutual learning and understanding and joint studies. It is believed that these programmes will better prepare the human resources for nuclear sciences and technology development in the Asia region.

5. OPERATOR TRAINING CENTRE

Thailand has one research reactor, TRIGA Mark III (TRR-1/M1). The reactor is used for medical isotope production, neutron activation analysis, doping silicon and other experiments for nuclear research and development.

The operator training centre was established at OAP since the reactor went critical. OAP offers courses for control room operator and shift supervisor. The training includes theoretical and on the job (practical) training. This training usually follows vocational training in nuclear, mechanical or electrical engineering and takes approximately two years to complete. Courses are systematically structured by learning objectives, and theoretical and practical parts are well organized and well coordinated. The course was established in the 1970s, therefore training assessment of the course should be conducted to re-evaluate the course and update the curriculum. The assessment will be conducted in 2005.

6. NUCLEAR REGULATORY AUTHORITY TRAINING CENTRE

The Ministry of Science and Technology (MOST) is responsible for the national nuclear energy policy. The nuclear facility licensing is authorized by the Bureau of Nuclear Regulatory Safety at OAP. The most important areas of the regulatory activities are licensing, supervising, analysing and inspecting the research reactor in Thailand. The regulatory authority has transferred the routine tasks to the operator of the research reactor. The operator is required to rigorously comply with the regulations. The inspection activities will be conducted by the regulatory authority to check compliance with safety regulations. The complex assessment activities, both deterministic and probabilistic, require experts from international organizations. OAP has given much importance to developing the human resources at all levels. Several training and workshop modules have been designed for the regulatory authority to build up the competencies and managing skills. The national and regional technical cooperation projects of the IAEA have been highly useful to strengthen the regulatory task in terms of human resource development. In addition to the above, the OAP has also derived significant benefit from the IAEA International Nuclear Information System (INIS) in the systematic exchange of knowledge and information.

7. PUBLIC INFORMATION CENTRE

Since inception, EGAT, OAP and AEDE have committed to help build the economy, both at national and local levels. All nuclear related institutes regularly participated in social activities and disseminated nuclear science and technology through the entrusted mission [6]. The programme includes a youth camp programme. Through the youth camp programme activities, young schoolchildren will acquire knowledge on energy development, energy conservation, environmental conservation, nuclear technology and application of nuclear techniques. The research reactor tour programme was established for young school students and the public to encourage them to learn from direct experience. The public information centre referred to as the call centre was established at OAP to provide nuclear information to the public. To promote the new research reactor, OAP launched a vocational training programme to maintain a good relationship with the communities. OAP and EGAT enhance the quality of life of people in remote areas by arranging activities to support educational and skills development. Normally OAP and EGAT provide scholarships for young students to study nuclear sciences [6].

8. THE PROBLEM OF NUCLEAR KNOWLEDGE MANAGEMENT IN THAILAND

The problem is due to the ageing of nuclear experts and the retirement of nuclear professionals in Thailand. Recently nuclear knowledge management has suffered because of a lack of experienced personnel in the nuclear field and the low rate of replacement of retired nuclear professionals. There is no nuclear power plant project planned to be constructed in the near future and, therefore, the younger generation is not attracted to the nuclear field. Only a few nuclear engineering students can find a career in the nuclear field. If there is no support from institutes, organizations and universities outside Thailand, the nuclear education programme and nuclear research facilities in Thailand will find it difficult to maintain nuclear knowledge.

9. CONCLUSION

Knowledge management and human resource development should be a national priority to promote and sustain the future possibility of the application of nuclear science and technology in the country. In the area of human resource development, the nuclear institutes and organizations in Thailand have adopted a competency based management system to enhance and align the employees' competencies with corporate strategies and vision so as to enable them to be the leading organizations in their respective fields. Thailand has established an effective national system for education and training in nuclear engineering and nuclear related fields. Strengthening collaboration in research and development through the international universities, other organizations and the ASEAN programme will provide for the growth of professional competence in nuclear science and technology. INIS has been integrated into the nuclear knowledge management programme in Thailand to promote knowledge transfer to the young generation. In addition, distance learning is also being promoted to fulfil the requirement of qualified staff. Political policies regarding sustainable development and alternative energy sources will have a strong impact on the nuclear knowledge management system, since the popularity of nuclear science and technology among students will decline if no nuclear power plant is envisaged. Nuclear education for the public, media, school students and teachers is important because they will acquire the knowledge to better influence the future decisions on the peaceful uses of nuclear power and nuclear technologies.

REFERENCES

[1] Electric Power in Thailand, Department of Alternative Energy Development and Efficiency, Ministry of Energy, 2003.

[2] Nuclear Education Program, Department of Nuclear Technology, Faculty of Engineer, Chulalongkorn University, 1999.

[3] NuTECH web site, http://161.200.86.32/details.html

[4] ASEAN web site, http://www.aseansec.org

[5] AUN web site, http://www.aun.chula.ac.th

[6] Power Experience: Electricity Energy for Thailand's Competitiveness, Electricity Generating Authority of Thailand, Annual Report (2005).

NETWORKING FOR EDUCATION, TRAINING AND KNOWLEDGE TRANSFER

(Session 5)

Chairperson

Y. YANEV
IAEA

WORLD NUCLEAR UNIVERSITY
Achievements and perspectives

Y. YANEV
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

Education and training involve passing knowledge to the next generation and sharing knowledge for capacity building. 'Education' in this context denotes higher education received in universities, etc., whereas 'training' denotes transfer of shorter, skill oriented specialized knowledge, which is usually done by the nuclear industry or organizations. Thus, education and training are considered as important tools for preserving and sustaining knowledge. Recently, the networking of educational institutions has been considered a key strategy for capacity building and the efficient use of available educational resources. The strength of the IAEA lies in its ability to propose and facilitate frameworks in which Member States can work together and collaborate. The paper describes the IAEA's approach to promote education and training through the World Nuclear University.

1. INTRODUCTION

Several international initiatives address the need for greater numbers of well qualified and educated nuclear industry recruits. The most recent of these is the World Nuclear University (WNU), launched in September 2003 by the World Nuclear Association (WNA). The founding supporters of the WNU are the IAEA, OECD/NEA, WANO and WNA and its membership covers 26 organizations worldwide [1].

The mission of the World Nuclear University (WNU) is to strengthen the international community of people and institutions so as to guide and further develop:

- The safe and increasing use of nuclear power as the one proven technology able to produce clean energy on a large global scale;
- The many valuable applications of nuclear science and technology that contribute to sustainable agriculture, medicine, nutrition, industrial

development, management of freshwater resources and environmental protection.

The WNU aims to be instrumental in creating a network of leading institutions of nuclear learning. The emerging worldwide partnership aims to:

— Enhance nuclear education among its members;
— Establish globally accepted standards in academic and professional qualification;
— Elevate the prestige of the nuclear profession.

The WNU is not a degree-awarding institution but a composite of its participating institutions, each of which will continue to teach and award degrees. Its mission is proposed to be accomplished through a worldwide network that coordinates, supports and draws on the strengths of established institutions of nuclear learning to promote academic rigour and high professional ethics in all phases of nuclear activity, from fuel and isotope supply to decommissioning and waste management.

A distinctive feature of the WNU is that there are no barriers to entry to its membership. It is a voluntary collaboration, which offers individuals and institutions the opportunity to bring their strengths, creativity and vision to the task of enhancing nuclear science and strengthening the nuclear profession for an ever wider global role.

2. WNU SUMMER INSTITUTE

Among WNU activities, the Summer Institute — as an academy for future leaders in nuclear science and technology — is currently at the most advanced stage [2]. The concept of a WNU Summer Institute was developed through WNA–IAEA collaboration.

Each year the Summer Institute will provide, to a select group of graduate students and young professionals drawn from all over the world, a period of intense high quality education designed to:

— Present cutting-edge knowledge and broad international perspectives on the full range of political, environmental and social issues surrounding the peaceful application of nuclear technology;
— Expose participants to the world's leading thinkers and educators in topics relevant to nuclear applications;

— Enable participants to experience practical teamwork and to establish lasting bonds with peers from many nations;
— Inspire participants to commit themselves to advancing the global contribution of nuclear science and technology.

The first Summer Institute was held in Idaho Falls, United States of America from 9 July to 20 August 2005. The fellows from 33 countries were graduate students or employees affiliated with 63 different organizations. Selected from among the world's leading nuclear students and young professionals, the WNU fellows participated in an intense six week educational experience featuring some of the foremost international leaders in science, engineering and the environment. The United States Department of Energy (DOE) provided leadership in launching this WNU innovation by generously agreeing to help sponsor the first annual WNU Summer Institute. The Programme of the 2005 WNU Summer Institute was designed at the WNU Coordinating Centre in London in cooperation with the WNU's four 'founding supporters': the IAEA, the OECD/NEA, WANO and the WNA. Fifty-two faculty members made presentations on 25 different topical areas. In addition, seven leaders in nuclear and related fields made presentations under the series named Lectures on Nuclear Leadership. These internationally recognized experts represented 15 different nationalities and most of them were supported by the organizations that employed them.

The WNU Coordinating Centre operates from London, in co-location with the WNA, focusing on conducting the WNU Summer Institute and coordinating the activities of the WNU's ten cooperative working groups, each of which comprises a worldwide group of experts in a particular nuclear or nuclear related discipline. One of these working groups is focused on knowledge management, with the goal of transforming the concept into an operational programme of action involving the world's leading nuclear companies and the WNU's institutions of nuclear learning.

REFERENCES

[1] http://www.iaea.org/km
[2] http://www.world-nuclear-university.org/html/summer_institute/index2005.htm

ROLE OF THE EUROPEAN NUCLEAR EDUCATION NETWORK ASSOCIATION IN THE MANAGEMENT OF NUCLEAR KNOWLEDGE

P.-P. DE REGGE
European Nuclear Education Network Association,
Saclay

Abstract

The temporary network, established through the European 5th Framework Programme project ENEN, was given a more permanent character by the foundation of the European Nuclear Education Network (ENEN) Association with the objective of preservation and further development of higher nuclear education and expertise. The activities of the ENEN Association are organized through five committees. During the 5th and 6th Framework Programme of the European Community, the ENEN Association made progress towards the delivery of the European Master of Science in Nuclear Engineering (EMSNE) certificate. Although the ENEN Association started with its focus on nuclear engineering education, the activities of its members within the scope of the 6th European Commission framework project NEPTUNO will expand into the definition, harmonization and transnational recognition of professional training for key functions in nuclear industries and regulatory bodies.

1. INTRODUCTION

The temporary network, established through the European 5th Framework Programme project ENEN, was given a more permanent character by the foundation of the European Nuclear Education Network (ENEN) Association, a non-profit-making association according to the French law of 1901, pursuing a pedagogic and scientific aim. Its main objective is the preservation and the further development of higher nuclear education and expertise. This objective is realized through cooperation between European universities involved in education and research in the nuclear engineering field, nuclear research centres and the nuclear industry.

2. ACTIVITIES OF THE ENEN ASSOCIATION

The activities of the ENEN Association are organized through the following five committees:

(1) The Teaching and Academic Affairs Committee establishes the equivalence between nuclear education curricula, awards the ENEN Master of Science Certification, promotes student and teacher exchanges, and organizes international ENEN courses.
(2) The Advanced Courses and Research Committee establishes exchanges with other networks and determines, through tight relations with research centres, universities and industry, suitable topics for internships and Master's theses.
(3) The Training and Industrial Projects Committee identifies the industrial needs for continued professional development. It organizes training sessions and courses on subjects of common interest for the ENEN associated members. Its role includes the European harmonization of professional training and certification of key positions in nuclear industry, which involves regulatory bodies in addition to the other stakeholders.
(4) The Quality Assurance Committee elaborates the quality assurance processes to be applied in the implementation of education and training programmes by the ENEN members. This committee also examines the quality assurance practices adopted in each institution.
(5) The Knowledge Management Committee identifies and monitors knowledge deficiencies relevant to nuclear technology and safety. It implements an action plan to ensure that valuable scientific knowledge is not lost. It develops the efficient use of information and communication technology (ICT) to support teaching and learning.

3. EUROPEAN MASTER OF SCIENCE IN NUCLEAR ENGINEERING CERTIFICATE

During the 5th and 6th Framework Programme of the European Community, the ENEN Association made progress in the implementation of the European Master of Science in Nuclear Engineering (EMSNE) certificate programme. In particular, education and training courses have been developed and offered at the ENEN member institutions, which established the EMSNE core curricula and the optional fields of study. Pilot editions of those courses and training programmes have been successfully organized with the support of nuclear industries and international organizations, and the results indicated a satisfactory interest, attendance and performance by the students. The courses conducted include several editions of the Eugene Wigner International Training Course for Reactor Physics Experiments; a seminar on the nuclear fuel cycle; an advanced nuclear safety course; courses on nuclear reactor theory, nuclear reactor physics, nuclear thermal hydraulics, radiation protection and nuclear measurements, nuclear safety for nuclear power plant subcontractors, kinetics and dynamics of nuclear reactors, and reactor design study projects; and a recent European course in cooperation with the European Utility Requirements Organization. Within ENEN, a consensus has been reached on the qualification of common curricula, an accreditation mechanism inspired by the Bologna Declaration and a mobility scheme for students and teachers.

4. CONCLUSION

Although the work of the ENEN Association started with and is still focused on nuclear engineering education, the activities of its members within the scope of the 6th European Commission framework project NEPTUNO will expand into the definition, harmonization and transnational recognition of professional training for key functions in nuclear industries and regulatory bodies. The involvement of ENEN in the 6th European Commission framework EUROTRANS project will further enlarge its field of activities into the realm of nuclear disciplines. It will be a challenging task, which will significantly contribute to the dissemination and management of nuclear knowledge within the European Union, as well as on a worldwide level, through ENEN's international contacts with its sister network, the Asian Network for Education in Nuclear Technology (ANENT) in Asia, and by its participation in activities of the World Nuclear University.

HIGH LEVEL EDUCATION IN NON-POWER NUCLEAR DISCIPLINES AND PARTNERSHIP WITH THE RESEARCH AND INDUSTRIAL WORLD

Example of the IUSS-University of Pavia Master's Programme on Nuclear and Ionizing Radiations Technologies

A. FAUCITANO
University Institute for Advanced Study (IUSS),
Collegio Giasone del Maino

A. BUTTAFAVA
Department of General Chemistry,
University of Pavia,

Pavia, Italy

Abstract

Seven years of experience in conducting a pioneering Master's course in the field of non-power nuclear disciplines is summarized together with a description of its curriculum. The contribution of the IAEA and the symbiotic interaction of the School with industries and external research institutions have enabled the course to attain economic justification and sustainability, and made the IUSS-University of Pavia the national reference centre for professional education and applied activities in the field. Another factor that contributed to this result is the uniqueness of Pavia as a university town (the second oldest university in Italy with 17 university colleges) with an outstanding tradition in nuclear research.

1. BACKGROUND

Academic and professional education in nuclear disciplines in Italy has flanked the history of nuclear energy utilization. From 1950 to 1980, the period of the most intense development of nuclear power, four nuclear power reactors (at the sites of Caorso, Latina, Trino Vercellese and Garigliano in Italy) were built and construction on the fifth was started at Montalto di Castro. Concomitantly, eight university faculties awarding a Master's of Science degree in nuclear engineering were founded at Turin, Milan, Genoa, Bologna, Palermo, Rome and Pisa. Another important event was the foundation of the European Atomic Research Centre (EURATOM) at Ispra, devoted to nuclear research and development activities. Within this scenario, the powerful national nuclear authority, the National Centre for Nuclear Energy (CNEN) operated up to 1987, when a referendum abolished the production of nuclear energy with immediate effect and the consequences on studies in nuclear disciplines were dramatic. The university faculties, with the exception of Bologna and partially Palermo, managed to keep the original nuclear engineering courses and research alive but suffered a progressive decrease of graduates; the Joint European Research Centre at Ispra had to switch to R&D activities in fields other than nuclear, such as environmental sciences. Finally, CNEN changed its institutional aims and its name to the National Agency for Alternative Energies (ENEA). However, parallel to this decay of nuclear energy programmes, novel disciplines, which can collectively be defined as 'non-power nuclear technologies' were silently and progressively developing in the country under the push of the demands stemming from the industrial sector and society. The use of particle accelerators and radiation sources in radiotherapy and for producing radioisotopes and radio-pharmaceuticals for nuclear medicine; the use of radioisotopes and ionizing radiations in industrial, environmental, food technology and agricultural activities; the applications, in many research fields, of nuclear analytical techniques originally developed for the detection of trace elements; development of radioecology and environmental radiochemistry methodologies; and finally, the emergence of the profession of 'qualified expert', dealing with radio-protection and safety procedures with respect to all the activities above. In addition, decommissioning of the existing nuclear power plants must be included as a major source of job and research opportunity. This wide variety of 'non-power' nuclear disciplines has given rise to a demand for professional skills, which could not be met by the existing nuclear courses and specialized schools and, therefore, called for the exploitation of novel courses with suitable teaching and training curricula. Eight years ago the perception of this reality prompted the University of Pavia and its branch, the University Institute for Advanced Study (IUSS) to launch a one year, second level Master's course on nuclear and ionizing radiations technologies, the first in Italy and probably in Europe, which has now completed its seventh academic year. A major pioneering characteristic of the Master's course is the partnership with external organizations (industries, academic institutions, national research centres, etc.) with their full involvement in curricula planning, teaching and professional training.

2. GENERAL ORGANIZATION OF THE MASTER'S COURSE

The Master's course is managed by the IUSS in partnership with the University of Pavia and the Ministry of Education, Universities and Research

(MIUR) which provides financial support [1]. Very recently (August 2005), the Ministry of Education awarded IUSS the status of an independent university under the leadership of R. Schmid, the former Rector of the University of Pavia. Partners of the Master's course are industries, several Italian and foreign universities, the National Research Council (CNR), ENEA and the Instituto Superiore di Sanita' (ISS). An essential element of this success is the collaboration with the IAEA through the Department of Technical Cooperation and the Department of Nuclear Energy, INIS Section. The applicants for the Master's Course must have a Master's of Science degree in one of the following disciplines: physics, engineering, chemistry, pharmaceutical chemistry, environmental science or biology. The selection is based on curricula and an oral colloquium. The Master's course has a one year duration. The first part consists of 400 hours of theoretical lectures and laboratory work giving a broad knowledge on non-power nuclear specialties. The second part is a training stage of six months' duration, which is performed in external institutions under a formal agreement with the School (IUSS) and the guidance of two tutors, one from the host institution and one from the School. This stage has the key role of focusing the student's learning on a specific professional specialty. At the end of the course, the students, who have passed the intermediate examinations and the final dissertation–thesis examination, are awarded the Degree of Master in Nuclear and Ionizing Radiations Technologies.

3. THE DIDACTIC PLAN OF THE MASTER'S COURSE AND THE RELATIONSHIP WITH INDUSTRIES AND EXTERNAL RESEARCH INSTITUTIONS

As mentioned above, the didactic programme of the Master's course consists of about 400 hours of theoretical lectures and laboratory work, followed by a six month training stage in external institutions. The theoretical section is organized in five modules as follows:

(a) Fundamental nuclear theory: radiation chemistry, radiation physics, radiochemistry, radiobiology, radiation detectors and radiation dosimetry;
(b) Ionizing radiation based technologies: radiation sources, industrial dosimetry; applications of radiations in industrial sterilization, material science, environmental chemistry, food technology and agriculture;
(c) Radioisotopes techniques: radiochemical methods and their applications in waste; characterization and environmental radiochemistry, the

cyclotron production of radioisotopes and their use in the synthesis of radiopharmaceuticals, and nuclear activation analysis and its applications;

(d) Radioprotection;

(e) Introduction to nuclear decommissioning.

This programme is a mirror image of the major non-power nuclear specialties which have become the basis of scientific research, as well as of stable and economically sustainable initiatives of industrial and societal interest in Italy. It was first necessary to make a careful survey for arriving at the definition of the panorama of nuclear activities in the country, both research and applications. The second step was to establish formal relationships with such nuclear activity centres in order to obtain their collaboration on three basic points: (a) the definition of the curriculum in the specialties section; (b) the contribution of specialists for lecturing and training stages; and (c) visits to the plants and laboratories with technical demonstrations. It is worth pointing out that the attitude of the external institutions was always extremely favourable, both because of the agreement with the educational aims of the project and also because of the satisfaction and motivation stemming from being actively involved in all the phases of the course.

The first module of the Master's course has the crucial role of implementing and synchronizing the basic nuclear knowledge of students coming from different Master's of Science courses. The second module is dedicated to the practical application of ionizing radiations. The reference research institutions for the School in this field were the radiation chemistry laboratories at the University of Pavia (Italy), Palermo (Italy), Lodz (Poland), Instituto per la Sintesi Organica e la Fotoreattivita' del CNR (ISOF-CNR) in Bologna (Italy), ENEA, the Instituto Superiore di Sanita' in Rome (ISS, National Health Institute), the Federal Centre for Nutrition and Food Research at Karlsruhe (Germany), the Seibersdorf Research Laboratory (Vienna), and the Electronic Institute at the Bulgarian Academy of Science. The list of industries contributing 'stages' and specialists to the School include the major producer of accelerators (IBA, Belgium); the major Italian companies providing general purpose irradiation services (Gammatom, Gammarad, Bioster) or those using built-in accelerators and gamma facilities for on-line sterilization of their own products (Gambro Dasco, Novico); two factories using electron beams for curing electric cables (Metallurgica Bresciana, Megarad); an R&D centre of a multinational using low power e-beams in multilayer-polymer-film food packaging technology (Sealed air Corporation); e-beam surface curing and synthesis of polymers composites (Alenia Space); electronic industries using nuclear technologies in semiconductor curing (ST Microelectronics: ion implantation; Ansaldo and ISOF-CNR: semiconductor e-beam curing); and the R&D laboratories of industries performing radiation damage tests on electronic circuitry and materials for the nuclear and space industry (Alenia Space). The third module has three major focal points as described below.

(1) *The production of radionuclides in cyclotrons and their use in the synthesis of radiopharmaceuticals.* The reference external research institutions in this field for the School are the CNR Cyclotron Laboratory at Pisa (Italy), the Instituto Nazionale di Fisica Nucleare (INFN) University Laboratorio Acceleratori e Superconduttività Applicata (LASA laboratory) in Milan (Italy), and the University of Padova (Italy). Of key importance for the School from the viewpoint of professional training in this field are, the positron emission tomography (PET) centres, normally located in important hospitals; such PET centres act as small factories distributed in the territory providing a complete line of radioisotope production (by cyclotron) and manufacture of radiopharmaceuticals (radiochemistry laboratory) and quality control. The number of PET centres is rapidly increasing in Italy: four of them are located in Milan and one in Pavia at the University in an interdepartmental nuclear laboratory, the Laboratory of Applied Nuclear Energy (LENA), where a nuclear research reactor is also located. Other PET centres formally connected with the School are operative in central Italy (CNR-Pisa) and south Italy (Naples).

(2) *The applications of nuclear activation analysis in environmental research, cultural heritage, forensic chemistry, material science and medical research*. The University of Pavia has an outstanding tradition in this field due to the availability of a TRIGA nuclear research reactor located at LENA.

(3) *Environmental radioisotopes detection and radiation monitoring.* Reference institutions for the School in this field are the research Laboratory of ENEA at Casaccia, Rome and Lerici (Italy); the European Joint Research Centers at Ispra (Italy) and Karlsruhe (Germany); well suited for professional training. A good source of job opportunities was found to be the State Agency for Environmental Protection (APAT) through its regional branches in Lombardia (Agenzia Regionale Prevenzione e Ambiente: ARPA-Milan and ARPA-Pavia) and Emilia Romagna (ARPA-Piacenza).

The programme of the fourth module is dedicated to radioprotection and safety procedures and it embodies the programme for the certificate of 'qualified expert'. Reference institutions for the School in this field are the Radioprotection Laboratories at LENA-Pavia and at ELECTRA-Synchrotrone in Trieste; and the Health Physics Laboratories of important hospitals in Pavia and Milan.

The fifth module is an introduction to nuclear facility decommissioning, which is entirely managed by specialists from SoGIN, which is a State owned company detached from ENEL, with the institutional aim of carrying out the decommissioning of existing nuclear power plants. SoGIN contributes teachers and training stages to the School. The students of the Master's course in this specialty do not become specialists of 'nuclear decommissioning' in the sense that they will not be able to manage the entire decommissioning process; instead they will acquire professional expertise in specific activities of nuclear decommissioning, such as radioprotection measures and radioactive wastes characterization and storage.

4. EXPERIENCE WITH THE MASTER'S COURSE

In the first six academic years of the Master's course starting from 1999, total of 89 students were awarded the Degree of Master of Nuclear and Ionizing Radiations Technologies, and another 19 students belonging to the seventh academic year will have their final dissertation thesis examination in the first half of 2006. The total number of applicants, including the current academic year, is about 350. A major part of the students attending the Master's course has a Master's of Science degree in physics (46%), followed by a Master's of Science degree in engineering (25%). The remaining 29% of the students have Master's of Science degrees in chemistry, pharmaceutical chemistry, biology and environmental sciences. Within three months after completion of the Master's course, about 30% of the students got a job offer or a fellowship within the training institutions. Other graduates were in the process of acquiring the Certificate for the profession of 'qualified expert' after passing the specific State examination. A follow-up analysis is now being launched in order to get an overview on their employment situation over the long term.

5. CONCLUSIONS

In its seven academic years, the IUSS-University of Pavia second level Master's course on Nuclear and Ionizing Radiations Technologies has demonstrated the economic justification and sustainability of high level professional education in non-power nuclear specialties, thus also contributing to the preservation of nuclear knowledge in a country that had suffered the consequences of adverse political decisions (the referendum). Due to the symbiotic relationship with industries and external nuclear research centres, the IUSS Master's course has become a reference institution for promoting debates, exchanges of ideas and initiatives of cultural and economic value in Italy. Most important, the Master's programme has become an observatory for the non-power nuclear activities capable of indicating the present success and future trends of each specialty. The School is also acting as a cultural forum for debates of economic and societal impacts. Thus in 2001 a seminar and a round table on the state of the art of the application of irradiation technology in food industry was organized with the participation of eminent international specialists and many national industries [2]. An international seminar on management of nuclear knowledge was organized in 2003 by the IAEA (INIS) in partnership with the School and with the participation of specialists from eight countries [3]. An initiative is now being implemented under the European ERASMUS programme for establishing the European Master's Programme on Nuclear Technologies under the coordination of the University of Grenoble, France.

REFERENCES

[1] Master web site, http://unipv.it/nuclrad

[2] FOSCOLO, A., "Novel techniques of sterilization in the food industry with ionizing radiations", Sem. University of Pavia, IUSS-University of Pavia, Pavia (2001).

[3] Nuclear Education: Problems, Methodologies and Perspectives, Proc. 1st Sem. IAEA and IUSS-University of Pavia, Ghislieri College, Pavia 2003.

ASIAN NETWORK FOR EDUCATION IN NUCLEAR TECHNOLOGY
An initiative to promote education and training in nuclear technology

A. KOSILOV
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna

Abstract

It has become increasingly clear that there is a need to consolidate the efforts of academia and industry in education and training. Partnerships of operating organizations with educational institutions and universities that provide qualified professionals for the nuclear industry should be assessed based upon medium and long term needs and strengthened where needed. In this regard the IAEA is taking the necessary action to initiate this kind of partnership through continuous networking. The paper describes the IAEA approach to promoting education and training through the Asian Network for Education in Nuclear Technology (ANENT).

Demand for energy and electricity has been increasing more rapidly in the developing countries of the Asian region than those in any other region of the world. It is becoming obvious that nuclear power will be one of the factors in the energy equation, supporting the efforts to meet the growing energy demand in this area, since it produces no greenhouse gases and well run nuclear power plants are currently the least-cost source of electricity in several countries.

Potential constraints in achieving the needed growth of nuclear programmes in the region include a shortage of qualified individuals and lack of a skilled workforce; the erosion of nuclear knowledge due to the decline in nuclear education programmes in the universities; decreased enrolment of students; and ageing faculty members. Besides, the demand for employees is not only for the operation of nuclear power reactors but also for increasing the application of nuclear technology in agricultural production, healthcare and industrial processes.

The type and level of education and training programmes in the Asian countries evolved based on the development paths followed for nuclear power and nuclear applications in each country, and as a result there is significant diversity among them. Apart from universities and institutions of higher education, various types of education and training in nuclear engineering and technology are also provided by national authorities responsible for nuclear technology development, research institutions, industry and professional associations. A network arrangement among nuclear institutions was recognized as a potential option to address the regional needs in this regard effectively and efficiently.

Following the first coordinating committee meeting organized by the IAEA in Kuala Lumpur, Malaysia, the Asian Network for Education in Nuclear Technology (ANENT) was established in February 2004, to promote, manage and preserve nuclear knowledge; to ensure the continued availability of talented and qualified employees in the nuclear field in the Asian region; and to enhance the quality of human resources for the sustainability of nuclear technology [1, 2].

Universities, research centres, government agencies and other institutions involved in nuclear education and training in the region, are accepted as participating members of ANENT and international or regional networks as collaborating members. Currently there are 17 participating institutions from 11 countries: China, India, Indonesia, Malaysia, Mongolia, Pakistan, Philippines, Republic of Korea, Sri Lanka, Thailand and Vietnam; and three networks (Asian School of Nuclear Medicine, European Nuclear Engineering Network and World Nuclear University) as collaborating members.

The mission of ANENT is to facilitate cooperation in education and training, and research and capacity building in nuclear technology through active knowledge management and knowledge sharing.

Important planned activities are:

— Sharing of information and materials in nuclear education and training;
— Exchange of students, teachers and researchers;
— Establishment of reference curricula and facilitating mutual recognition of degrees and transfer of credits;
— Facilitating communication between participating members and other regional and international networks.

The focus of ANENT in the short and medium term would be on enlarging the number of participating institutions; full operation of the ANENT web portal for sharing resources; and developing curricula, with pilots in nuclear engineering and nuclear medicine/radiation therapy. IAEA support for educational networks such as ANENT is essential as the IAEA plays a leading role in establishing and maintaining these networks through coordination of the efforts by the Member States involved. Educational networking is considered now as a key strategy for capacity building and better use of available educational resources. Establishing and supporting similar education networks is considered essential for other world regions such as Latin America and Africa.

REFERENCES

[1] http://www.anent-iaea.org
[2] http://www.iaea.org/km

NETWORKING FOR CAPTURING AND PRESERVING EXISTING KNOWLEDGE

C.L. VETERE, M. EPPENSTEIN
Atomic Energy Commission (CNEA),
Buenos Aires, Argentina

Abstract

In order to capture nuclear knowledge in key areas that might be lost due to organizational evolution and the ageing of human resources, CNEA has promoted three projects with specific strategic objectives: LICREX (Research Reactors Knowledge Book), knowledge preservation of the Atucha type reactor and CLAMN (Nuclear Medicine Knowledge Latin American Net). Using knowledge management techniques and taking advantage of Information and Communications Technologies (ICT) corporative resources, these projects are intended to protect, preserve and capture a part of the intellectual property generated by the Argentinian nuclear sector.

1. EVOLUTION OF THE ORGANIZATION

From 1950 to 1994, CNEA was the only organization with competence in nuclear activities (R&D, human resource management, nuclear power and regulatory issues). From 1976, new organizations associated with CNEA have been created, under different legal and organizational frameworks. They constitute the other components of the Argentinian nuclear industry and are described briefly below:

— INVAP S.E. was founded in 1976. Although its total stock is owned by the province of Rio Negro, it is run just like any private enterprise and is a technology based company. Using a multidisciplinary approach, it develops technology in several different areas of nuclear, space and certain special aspects of industrial projects. This process consists of some or all of the steps of complex projects, including feasibility studies, development, design, engineering, purchasing, construction, equipment erection, startup, and operation and maintenance in the nuclear area. This company builds and commissions complex facilities and equipment for peaceful uses of nuclear technology, such as research reactors for training, research and radioisotope production; facilities and equipment for manufacturing of nuclear fuel; radioisotope production plants;

radiopharmaceutical synthesis and fractioning facilities; irradiation facilities; dry storage systems for spent nuclear fuel; radiological monitoring and control equipment for scientific, industrial and medical applications; and provision of services and custom-built equipment tailored to the requirements of the Argentinian nuclear power plants in operation. CNEA designates four of the seven members of the Board of Directors.

— CONUAR S.A. (Combustibles Nucleares Argentinos S.A.) is owned jointly with 33% of the stock held by CNEA and 67% of the stock by the Perez Companc Group. This company manufactures uranium pellets (both natural and low enriched) and complete fuel assemblies; supplies reactor and nuclear facility services; research reactor fuel elements (up to 20% enrichment), reactivity control assemblies including cobalt targets; designs and manufactures special tools and manipulators for reactor internals and hot cells; and several other devices for the nuclear industry.
— FAE S.A. (Fábrica de Aleaciones Especiales S.A.) is a subsidiary company of CONUAR S.A., which manufactures structural components and Zircaloy cladding tubes for nuclear fuel elements (CNEA owns 32% of the stock).
— FUESMEN (Fundación Escuela de Medicina Nuclear) is a foundation constituted by three organizations: Cuyo University, Mendoza Province and CNEA. Its principal objectives are training, provision of diagnostic services by imaging, and treatment using nuclear medicine.
— ENSI S.E. (Empresa Neuquina de Servicios de Ingeniería S.E.) is a State owned corporation, founded in 1989 that is jointly owned by CNEA and Neuquen Province. It operates the industrial heavy water production plant that is owned by CNEA and sells reactor grade heavy water to natural uranium fuelled nuclear power plants. Due to the area, expertise and competence of its staff, it has been providing engineering services since 1995 to local industries (mainly chemical, oil, petrol and gas companies).
— DIOXITEX S.A. is a company jointly owned by CNEA and Mendoza Province. It was created for manufacturing uranium dioxide powder for the production of fuel pellets. Since 2002, this company has diversified into the production and marketing of ^{60}Co sealed sources.

In 1994, two new public organizations were created:

— The Nuclear Regulatory Agency (ARN) is an independent government agency responsible for the regulation and supervision of all activities related to: nuclear and radiological safety; physical protection and control

of the use of nuclear materials; licensing and surveillance of nuclear facilities; and international safeguards.
- Nucleoeléctrica Argentina S.A. (NA_SA) is an independent public limited company that owns and operates the two nuclear power plants in operation (Atucha I and Embalse). It is also responsible for completing the Atucha II Project, a third nuclear power plant currently under construction.

Since the establishment of the above two organizations, CNEA retains only R&D activities in different nuclear areas related to radioactive waste, reactors, fuel cycle, radioisotopes; radiation applications; and sciences (materials, chemistry, physics, mathematics and radiobiology).

The nuclear sector, considered as a group, employing about 4600 persons, has achieved a great relevance in the development of the Argentinian science and technology system. During the last five decades it has made significant contributions in different fields, such as energy generation, environmental protection, medicine, food preservation, agriculture, materials technology and quality control.

Although the Argentinian nuclear industry had to overcome several constraints on its growth, both local and international, it has been able to expand its technological abilities to other fields as well ('spin-off') due to the links established between the nuclear sector and the local engineering industry. It has also made significant achievements in the international sphere by exporting research reactors, technology for fabrication of fuel elements, and transferring know-how in the development and application of radioisotopes and radiation technologies to human health. Figure 1 shows the knowledge areas developed by the different organizations.

2. HUMAN RESOURCE EVOLUTION

Due to internal and external events, growth periods of Argentinian nuclear energy development have been unbalanced. Between 1975 and 1985, sizeable financial and human resources were assigned to the nuclear sector. Global bids were invited for setting up nuclear power plants and associated facilities. Construction of some research reactors and nuclear power plants began during this period. In 1980, CNEA staff strength rose to 6300 employees. It was expected that Argentina would commission one nuclear power plant every two years. During the 1990s restrictive policies were introduced in the public sector to reduce the human resources and financial support by the

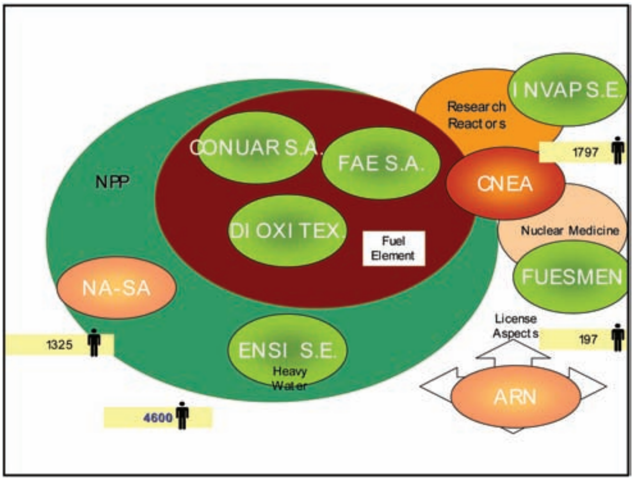

FIG. 1. Argentinian nuclear sector.

Government. New recruitment in the public sector was forbidden and retirement of employees was encouraged, resulting in an ageing workforce of professionals and technicians. During the period 2000–2003, total staff decreased by 2300. Figure 2 shows the age distribution in CNEA (R&D organization) and Atucha nuclear power plant units I and II. They look similar and the average ages of the two organizations are almost the same.

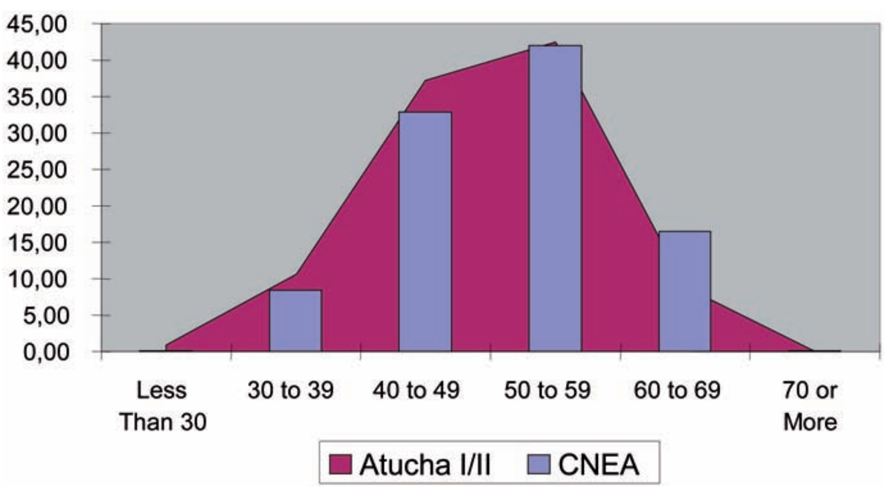

FIG. 2. R&D organization and utilities – age distribution.

In 2004, 60 young people were recruited by the CNEA and hopefully the scenario will improve in the future.

3. KNOWLEDGE MANAGEMENT PROJECTS

Recognizing the need for capturing and preserving the knowledge and experience of retiring experts and the intellectual property of the organizations, some important initiatives have been taken which are briefly described below.

3.1. LICREX: Research Reactors Knowledge Book

Under this scenario, CNEA used a step-by-step methodology and began the first knowledge management project related to research reactors called LICREX (Research Reactors Knowledge Book).

The strategic objective is to capture all the existing knowledge in the field of research reactors and promoting innovations in this key area.

The criteria for selection of this knowledge domain are that it is:

(1) One of the main activities of CNEA;
(2) An Argentinian export product (exported to Peru, Egypt, Algeria and Australia at the moment);
(3) Used to produce radioisotopes;
(4) Used in the past development and production of fuel elements, as the first Argentinian nuclear reactor was built in 1958 on an entirely indigenous basis;
(5) Used in the development of human resources;
(6) A tool for R&D, both in basic sciences and in nuclear sciences, and applications at CNEA and other R&D institutions.

Designers, customers and operators of the five Argentinian research reactors will have access to a thematic net. This intranet will be developed in successive steps with the primary objective of creating a cooperative culture, with dissemination criteria and elicitation mechanisms improving and capitalizing on the expertise in this area. The users of this intranet would be experts in subjects related to research reactors (nuclear physics, thermohydraulics, fuel element design and fabrication, operation and maintenance, and so on). Technical documents, drawings, operational records, regulatory documents, publications, expert's pages, and videos are some of the different formats in which the information is available.

It was initiated as a pilot project applied to RA1 (the first Argentinian research reactor).

The phases of the project are:

(1) Software and hardware infrastructure evaluation;
(2) Building knowledge maps;
(3) Determining critical knowledge;
(4) Intranet web site design;
(5) Application of capture techniques (expert accounts, videos, expert meetings, etc.).

Tools developed include:

— Massive categorization of documents;
— Thesaurus and synonyms.

Workshops attended by old and new experts, as well as interviews with experts were some of the methods applied with good results in capturing tacit knowledge. The old experts were in the age range of 70–75 years. Knowledge map navigation (in the research reactor knowledge domain) and different ways of searching data using keywords, type of documents, authors and text are some of the functions of the research reactors knowledge book.

3.2. Knowledge preservation of Atucha type reactor project

The strategic objective of this project is preserving and capturing critical knowledge on Atucha type reactors to enable the completion of construction of Atucha nuclear power plant unit II and the life management and licence extension of units I and II.

The reasons for the choice of this project include the following:

(1) Nuclear sector personnel are ageing and numerous employees are close to retirement.
(2) Siemens, the original designer, transferred its nuclear activities to Framatom ANP and future support services might not be available, as this type of reactor is not being built anywhere.
(3) Few young people are taking up studies in nuclear disciplines.
(4) It is necessary to capture all available knowledge (explicit and tacit) on this reactor type and provide easier access to future managers and workers on operation, maintenance and eventual decommissioning.

Atucha nuclear power plant unit I has been in operation for 30 years and unit II has been in construction for over 20 years. Many people were involved in these projects and large amounts of data have been collected over the years. The need is to identify the databases, documents, experts and knowledge that is critical. A comparative analysis of the status of the two units with respect to knowledge management aspects is given in Table 1.

When the knowledge preservation project began, the installed hardware and software infrastructure were evaluated to be critical due to obsolescence of the information technology used in two applications related to technical document management. The knowledge preservation project migrated the database used for these systems and developed the programs necessary to manage them, thus resolving satisfactorily the critical aspect. The knowledge preservation project will use a knowledge management portal to manage the critical knowledge of Atucha nuclear power plants. This ICT resource will work with an additional intranet server that does not interfere with the current

TABLE 1. A COMPARATIVE ANALYSIS WITH RESPECT TO KNOWLEDGE MANAGEMENT OF THE NUCLEAR POWER PLANTS ATUCHA I AND ATUCHA II

ITEM	ATUCHA I NPP	ATUCHA II NPP
Phase of plant life cycle	Operation	Construction
Information technology aspects (site network)	Network (servers and workstation). Some critical software in individual PCs	Mainframe computers and terminal. Many applications are stored on magnetic tapes.
Information technology aspects (intranet and extranet)	Available	Available
Software and applications in use	Many databases for different purposes (MS, SQL, Oracle, Dbase, WinIsis). Applications in VisualC, Fortran, Visual Basic	Critical softwares only available for mainframe
Electronic document management	Documents available in different formats (wordproccesors, spreadsheet). A few in pdf, html. Some drawings in CAD, videos	Huge quantity of documents in hard copy. Civil engineering drawings are being digitalized. Recent documents in commercial softwares.

system operating in the plant. Items will be entered as usual in each local server following the usual workflows. This knowledge management tool will establish communication between the servers and access to necessary stored data, capturing all new knowledge.

3.3. CLAMN project: Nuclear Medicine Knowledge Latin American Net

At the moment, CNEA is promoting an Acuerdo Regional de Cooperación para la Promoción de la Ciencia y Tecnología Nucleares en América Latina (ARCAL) project, which involves the development of a Latin American site dedicated to regional specialists in the areas of nuclear medicine, radiochemistry and radiopharmacy. The strategic objectives are to share experience on technical aspects; to facilitate contacting and utilizing human resources in the region; to develop new products; to facilitate the development and application of nuclear energy and technologies in the field of human health.

4. CONCLUSION

With specific strategic objectives, the current projects are being designed using knowledge management techniques, and ICT corporate resources in order to protect, preserve and capture a part of the intellectual property generated by the Argentinian nuclear sector.

BIBLIOGRAPHY

Bibliothèque de critères, Club Gestion des Connaissances, Paris (2003).

COMISIÓN NACIONAL DE ENERGÍA ATÓMICA, La Política Nuclear Argentina — Evaluación y Propuestas de la Comisión Nacional de Energía Atómica, CNEA, Buenos Aires (2001).

COMISIÓN NACIONAL DE ENERGÍA ATÓMICA, Memoria y Balance, CNEA, Buenos Aires (2003).

COMISIÓN NACIONAL DE ENERGÍA ATÓMICA, Memoria y Balance, CNEA, Buenos Aires (2001).

EPPENSTEIN, M., VETERE, C., Knowledge Preservation of Atucha Type Reactor: Practical Approaches and Lessons Learned (2004).

ERMINE, J.-L., La Gestion des connaissances, Lavoisier (2003).

INTERNATIONAL ATOMIC ENERGY AGENCY, Managing Nuclear Knowledge, IAEA, Vienna (2003).

PEIL, O., AUBERTIN, G., ERMINE, J.-L., Nada Matta, La cartographie des connaissances critiques, un outil de gestion stratégique des connaissances (2001).

THE EUGENE WIGNER COURSE
An example of international cooperation

C. SÜKÖSD
Budapest University of Technology and Economics,
Budapest, Hungary

Abstract

The Eugene Wigner Course is an international training course organized on a yearly basis by four universities in different countries in the Central European region. It is a product of the European Nuclear Education Network (ENEN) Association and is financially supported by the IAEA. In order to preserve existing nuclear knowledge, international cooperation is necessary on different levels. The lessons learned from such a course would be helpful to other institutions that intend to organize similar courses on an international basis.

1. INTRODUCTION

The Eugene Wigner Course for Reactor Physics Experiments (more information is available at http://www.reak.bme.hu/nti/Education/Wigner_Course) is a joint venture of the following European universities (in alphabetical order): Atominstitut der Österreichischen Universitäten (Vienna) Austria, Budapest University of Technology and Economics (Hungary), Czech Technical University Prague (Czech Republic), and Slovak Technical University Bratislava (Slovakia). It is a good example of international cooperation in the field of nuclear education. The participants of the course perform reactor physics experiments on three different nuclear research reactors in three different countries. The Quality Assurance Committee of the European Nuclear Education Network (ENEN) Association assessed this course and suggested that it should be referred to as an ENEN International Exchange Course. The IAEA provided financial support to some of the participants of the course. Since 2003, the course is being organized annually. There are several lessons that can be learned from the past three courses and it would be useful to share them with the nuclear knowledge management community.

2. HISTORY AND BACKGROUND

Cooperation between the four institutions mentioned has a long standing tradition. They were exchanging students between their facilities nearly every year for performing reactor physics experiments. However, this cooperation was mostly bilateral and organized on a case by case basis.

At the international level, the OECD Nuclear Energy Agency prepared a paper by the turn of the 21st century entitled “Nuclear education and training: Cause for concern?” Somewhat later, the European Union’s CCE-FISSION Working Group on Nuclear Education, Training and Competence prepared a Reflection Paper in 2000, which stated that:

> “Although the number of nuclear scientists and technologists may appear to be sufficient today in some countries, there are indicators that future expertise is at risk. In most countries, there are now fewer comprehensive, high quality nuclear technology programs at universities than before. The ability of universities to attract top quality students, meet future staffing requirements of the nuclear industry, and conduct leading-edge research is becoming seriously compromised.”

All over Europe the number of students choosing nuclear specialization was rapidly decreasing and the number of diploma level works and PhD theses were also falling rapidly every year. There were nuclear departments dissolved at universities, so even these few students could not always get high quality nuclear education in all nuclear topics. To tackle this problem, the 5th Framework Program of the European Union supported a project where a number of European universities, at which nuclear subjects were still taught, were brought together, in order to share their human resources and infrastructure to harmonize and improve nuclear education throughout Europe. This project was called ENEN. Among many other goals, the project had a ‘Workgroup 10a’, which had the task to set up an ‘experimental pilot session’ of international cooperation in nuclear education.

The objectives of the Workgroup 10a were to:

— Study the feasibility of creating international courses;
— Organize a ‘pilot course’;
— Make the course financially ‘self-supporting’ and ‘sustainable’.

Since the four universities mentioned were already collaborating with each other, they became the participants of this workgroup. The Budapest University of Technology and Economics was nominated as the leader of this work programme. As a result of the efforts of this group, the Eugene Wigner Course for Reactor Physics Experiment was defined, and performed successfully for the first time in April 2003.

After the end of the 5th Framework Program the institutions participating in the ENEN project decided to establish a legal entity called the ENEN Association, which now brings together many universities and other nuclear related institutions all over Europe. The Eugene Wigner Course of Reactor Physics Experiments is still being organized on a yearly basis, as an international course of the ENEN Association.

3. ORGANIZATION OF THE EUGENE WIGNER COURSE FOR REACTOR PHYSICS EXPERIMENTS

The purpose of the course is the experimental and theoretical training of students and young professionals in reactor physics through practical exercises at three different research reactors. The ENEN Association recommends six credits under the 'European credit transfer system' (ECTS) to those participants who successfully finish the course.

3.1. Group work

The participants work in groups consisting of four to five students. In forming the groups, special care is taken to mix the students in terms of nationality and gender (Fig. 1). This way, the international character of the

FIG. 1. Group of participants at the Atominstitut (Vienna).

course is emphasized, and the use of the English language is encouraged. The students travel and work together in a group, and they also prepare reports together. However, they are evaluated and graded individually at the oral evaluation of the report by the experiments' supervisor at the final evaluation session.

3.2. Schedule

The overall schedule is shown in Fig. 2 (Wigner Course in 2004). The letters A, B, C and D denote the different groups. The course was 18 days long, as can be seen in the first row (the red numbers are Sundays).

The course started with theoretical lectures in Bratislava, Slovakia, where all students participated. On the fourth day, a technical tour was organized to the Jaslovske Bohunice nuclear power plant (Slovakia), and a waste disposal place nearby. On the fifth day, the groups separated and travelled to other countries, where they performed practical experiments on the different research reactors. Some groups exchanged places in the middle of the week; others stayed the whole week in one place. The second week was similar, only the place of the different groups changed. This way every participant performed the same practical experiments, and visited all three research reactors. At the end of the course (18th day) all participants gathered again — this time in Vienna — where an overall evaluation session took place in front of a jury composed of professors of the participating institutions. As can be seen, the logistics of the whole course were quite complicated, but were successfully handled without any problem.

4. CONTENT OF THE COURSE

4.1. Lectures (programme in Bratislava)

The following lectures were offered:

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
SUT Bratislava	A,B,C,D																	
BME Budapest						A,B							C,D					
AI Vienna						C			D				A			B		ABCD
CVUT Praha						D			C				B			A		

FIG. 2. Time schedule of the Wigner Course 2004.

— Nuclear safety: V. Slugen, STU (Bratislava);
— Survey of research reactors and associated systems: M. Villa, Atominstitut (Vienna);
— Data evaluation techniques related to the practical exercises: Z. Szatmáry, BME (Budapest);
— Radiation protection and dosimetry: P. Zagyvai, BME (Budapest);
— Detector of radiation: M. Miglierini, STU (Bratislava);
— Instrumentation for nuclear measurements: S. Czifrus, BME (Budapest);
— Technical visit to Jaslovske Bohunice nuclear power plant (Fig. 3): J. Hasčik, STU (Bratislava).

The lectures were directly related to the practical experiments. Only a few lectures were included, which were necessary to enter the nuclear installations (e.g. about radiation protection and nuclear safety).

4.2. Experiments at the training reactor of BME Budapest

The following experiments were undertaken (Figs 4, 5):

— Reactor operation exercise;
— Determination of delayed neutron parameters and uranium content of a sample;
— Measurement of thermal neutron diffusion length in graphite;
— Reactivity worth of neutron absorbers;
— Neutron activation analysis.

FIG. 3. The participants of the Wigner Course visit the Jaslovske Bohunice nuclear power plant.

FIG. 4. Reactor operation exercise, BME Budapest.

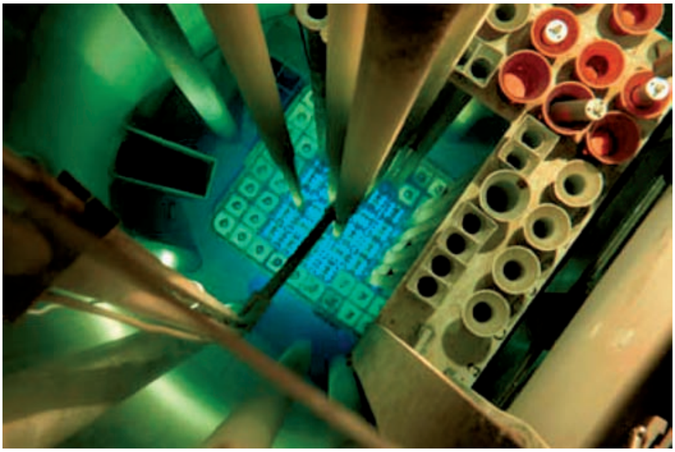

FIG. 5. Cerenkov radiation in the reactor core, BME Budapest.

4.3. Experiments at the VR-1 reactor of CTU Prague

The following experiments were undertaken (Figs 6, 7):

— Properties of neutron detectors for nuclear control;
— Measurements of reactivity by various methods;
— Calibration of control rods;

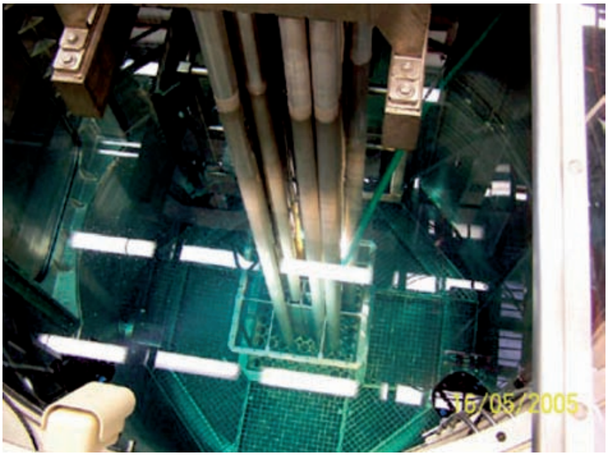

FIG. 6. View into the VR-1 reactor of CTU Prague.

FIG. 7. Students measuring in the CTU Prague.

— Study of nuclear reactor dynamics;
— Digital control and safety system of research reactors;
— Startup and operation of the VR-1 reactor.

4.4. Experiments at the TRIGA reactor of the Atominstitut (Vienna)

The following experiments were undertaken (Fig. 8):

— Measurement of the thermal neutron flux density in the reactor core;
— Determination of the neutron absorption cross-section;
— Determination of reactivity value of uranium fuel and graphite elements in different reactor positions;
— Criticality experiment;
— Determination of the importance function and the void coefficient;
— Reactor power calibration and determination of reactivity temperature coefficient;
— Demonstration of reactor pulses with different reactivity insertion.

5. QUALITY ISSUES

5.1. Qualifications of the staff

The lecturers/experiment supervisors have to fulfil the following requirements:

— Should be regular university professors or associate professors;
— Have a PhD degree in science;

FIG. 8. Group of students at the TRIGA reactor, Atominstitut (Vienna).

— Have at least five years of teaching experience in the field;
— Should be internationally recognized.

5.2. Assessing the students' work

During the experiments, groups have to write laboratory reports, where:

— The measurement is described;
— The raw measured data are indicated;
— The data evaluation method is outlined;
— The results are presented and discussed.

The written laboratory report is assessed (graded) by the experiment's supervisor.

Final evaluation session (last day):

— Each group chooses an experiment for oral presentation;
— Every student of the group is involved, he or she has to present some part of the subject;
— Each presentation is followed by a discussion where every participant and the members of the jury take part;
— An international jury composed of selected professors of the Organizing Committee assesses the presentations.

6. ASSESSMENT AND EVOLUTION OF THE WIGNER COURSE

6.1. Assessment

The organizers assess the quality and draw the lessons learned from the Wigner Course every year. The assessment is twofold:

— The Organizing Committee has a meeting after the course, where it assesses the actual course;
— After the 'final evaluation session' the participants are asked to write anonymous feedback reports, which are also taken into account in the assessment procedure.

After the assessment, the main outline of the next year's course is determined. Special care is taken to harmonize:

— The content of the theoretical courses and the experiments;
— The content of the laboratory experiments in the different laboratories.

This regular assessment results in the continuous evolution of the content and the logistics of the Eugene Wigner Course.

6.2. Evolution of the Wigner Courses

In 2003, the first course:

— 21 day course;
— Large number of theoretical lectures;
— Reactor physics basic lectures also included;
— Theoretical lectures not always relevant to the laboratory experiments;
— Three similar experiments in different laboratories.

In 2004:

— 18 day course;
— Reduced number of theoretical lectures;
— Only topics relevant to the experiment are retained and new topics included;
— Different experiments in different laboratories.

In 2005:

— Structure and content as in 2004;
— Only two groups instead of four;
— Opened also for young professionals (not only for university students).

The statistics of the participation in the courses during the past three years are shown in Fig. 9.

There were a total of 47 participants from 12 countries and their distribution according to degrees was: 35 MSc students, 7 PhD students, and 5 young professionals.

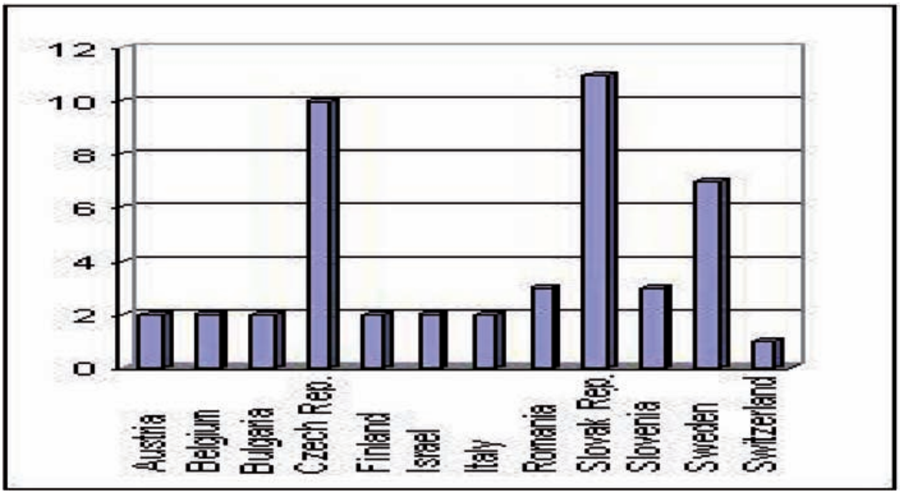

FIG. 9. Statistics of participation by country.

7. FINANCES

When the Wigner Course was defined, the Organizing Committee had a task to define it as ‘self-financing’ and ‘zero-balanced’. The expenses of the course fall into two categories:

— Cost proportional to the number of students (students’ costs or variable costs):
  - Students’ accommodation during the course;
  - Travel costs during the course between the countries;
  - Course material (textbook, laboratory manuals, printing, etc.);

— Cost independent of the number of students (fixed costs):
  - Reactor operation (2 weeks, 3 reactors = 30 reactor days);
  - Lecturers’ honorary (32 hours lectures);
  - Other organizational costs (postage, telephone, lecture room rental, opening and closing ceremony, overheads at the four organizing institutions, etc.).

The ‘zero-balanced’ condition means that all these costs should be covered by either the participants or their nominating institution or by some other external financial aid.

In this respect it may be stated that without external financial support the Wigner Courses could not have been performed. Table 1 summarizes the participation fees and the number of participants in the three courses performed

In 2005, the participants could choose between two options: to arrange their accommodation and travel (during the course) themselves, or through the organizers. The cost of the latter was 1200 euros. All participants chose the second option. The strategy of the ENEN organization is to give large reductions to the students of other ENEN member institutions and hence those students were given a waiver of the tuition fee. The reason for the higher participation fee for non-ENEN members is twofold: first, the smaller number of students has led to a larger proportion of the 'fixed-costs' in the participation fee; and second, the condition of zero-balancing and the reduced fee for ENEN-students resulted in a higher participation fee from non-ENEN participants.

Table 1 shows that we tried several options in the past three years for financing the Wigner Course. We conclude however, that none of them would have worked, if there were no support from external sources. This means that neither the participants individually, nor their sending institutions (mainly universities) were in a position to pay the participation fee. The IAEA has contributed to all the three courses by financing partly or completely a certain number of participants. This shows the lack of availability of financial–technical means and practices at most of the educational institutions to enhance the mobility of their students. If these internationally organized knowledge preserving courses are to be continued, financial support from international institutions, such as the IAEA, European Union, WNU and ENEN, is indispensable.

TABLE 1. SUMMARY OF FEES AND NUMBER OF COURSE PARTICIPANTS

Year	Participation fees (euro)	No. of participants
2003	2100	18 students 2 professionals
2004	1900	18 students 1 professional
2005	700 + 1200 (ENEN) 3500 + 1200 (non-ENEN)	8 students 2 professionals

8. THE ‘WIGNER COURSE’ IN 2006

Taking into consideration the lessons learned from the previous courses and reactor availability in the participating institutions, the Organizing Committee took the following decisions for the Eugene Wigner Course in 2006:

— The course will be from 4 to 22 September 2006;
— The number of participants will be limited to 10 (distributed to groups A and B);
— Participation fee will be the same as that in 2005. This means 700 + 1200 euros for ENEN students and 3500 + 1200 euros for non-ENEN students;
— The smaller number of students enables changing the logistics:
  - All participants travel together all the time (no exchange in the middle of the week);
  - 2 days theoretical lectures in Bratislava;
  - 1 day technical tour to a nuclear power plant near Bratislava;
  - 1 day travel Bratislava–Prague and individual work;
  - 3 days reactor experiments in Prague;
  - 1 day travel Prague–Vienna and individual work;
  - 3 days reactor experiments in Vienna;
  - 1 day travel Vienna–Budapest and individual work;
  - 3 days reactor experiments in Budapest;
  - 1 day technical tour to a full scale nuclear power plant maintenance centre in Hungary;
  - 1 day individual work for preparation for the final evaluation;
  - 1 day final evaluation in Budapest;
  - Total duration of 18 days;

— Applications for the Wigner Course 2006 should be sent not later than 31 May 2006, to C. Sükösd, Budapest University of Technology and Economics, Institute of Nuclear Techniques, H1521 Budapest, Hungary.

CHAIRPERSONS OF SESSIONS

Opening Session	A. KOSILOV	IAEA
Session 1	Y. YANEV	IAEA
Session 2	A. TOLSTENKOV	IAEA
Session 3	T. MAZOUR	IAEA
Session 4	A. KOSILOV	IAEA
Session 5	Y. YANEV	IAEA
Panel Discussion 1	Y. YANEV, A. KOSILOV	IAEA
Panel Discussion 2	A. TOLSTENKOV, Y. YANEV	IAEA
Panel Discussion 3	R. WORKMAN, T. MAZOUR	IAEA
Panel Discussion 4	Y. YANEV	IAEA
	J. BOYLES	USA
	A. KOSILOV	IAEA
Closing Discussion	Y. YANEV, A. KOSILOV	IAEA

SECRETARIAT OF THE WORKSHOP

Y. YANEV	Scientific Secretary (IAEA)
A. KOSILOV	Scientific Secretary (IAEA)
C. TUNIZ	Liaison Officer (Abdus Salam International Centre for Theoretical Physics)
J. RITCH	Liaison Officer (World Nuclear University)
N. PEREPPADAN	Workshop Organizer (IAEA)
D. GIOMBI	Workshop Organizer (Abdus Salam International Centre for Theoretical Physics)
M.R. KOORAPATY	Technical Editor
S. CLEMENTS	Proceedings Editor (IAEA)

LIST OF PARTICIPANTS

Alejeva, L.	ITECA UAB, Lithuanian Nuclear Power Safety Inspectorate (VATESI), Kalvariju Str. 125, 08221 Vilnius, Lithuania Fax: +37052769227 Email: alejeva@viti.lt
Anagnostakis, M.	National Technical University of Athens, School of Mechanical Engineering, Department of Nuclear Engineering, 15780 Athens, Greece Fax: +302107722914 Email: managno@nuclear.ntua.gr
Beraha, D.	Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS), Forschungsgelände, 85748 Garching b. München, Germany Fax: +498932004301 Email: bea@grs.de
Bernido, C.C.	Philippine Nuclear Research Institute, P.O. Box 213 UP, Diliman, Quezon City, Philippines Fax: +6329201646 Email: cber@info.com.ph
Boyles, J.E.	Tennessee Valley Authority, 1101 Market Street Chattanooga, Tennessee 37402 –4885, United States of America +432-751-2118 Email: jeboyles@tva.gov
Bright, C.K.	British Nuclear Group, Safety & Risk Management (H280), Hinton House, Risley, Warrington, Cheshire WA3 6AS, United Kingdom +441925833930 Email: clive.k.bright@bnfl.com

Buza, K.	Paks nuclear power plant, P.O. Box 71, 7031 Paks, Hungary 3675507056 Email: buzak@npp.hu
Danac, D.	Bohunice nuclear power plant, SE. a.s. Odd. 61220, 91931 Jaslovste, Bohunice, Slovakia 421335971513
de Grosbois, J.	Projects and Process Section, Information and Control Systems Division, AECL, Building SP1, Location E-331, 2251 Speakman Drive, Mississauga, Ontario, L5K 1B2 Canada Fax: +9054037376 Email: degrosboisj@aecl.ca
De Regge, P.-P.	ENEN, INSTN, CEA/Saclay, 91191 Gif sur Yvette, France Fax: +33169089950 Email: peter.de.regge@sckcen.be; sec.enen@cea.fr
Didier, P.	Responsable de l'antenne des Angles, Assistant à la DSU, 550, rue de la Tramontane, B.P. 70295 Les Angles, 30402 Villeneuve Avignon Cedex, France Fax: +0490261132 Email: didierperrault@irsn.fr
Duff, B.	Senior Regulatory Documents Officer, Canadian Nuclear Safety Commission (CNSC), P.O. Box 1046, Station B, Ottawa, Ontario, KIP 559 Canada Fax: +6139955086 Email: Duffb@cnsc-ccsn.gc.ca
Faucitano, A.	Director of the IUSS–University of Pavia, Master on Nuclear and Ionizing Radiations Technologies, University of Pavia, V. le Taramelli 12, 27100 Pavia, Italy Email: antonio.faucitano@unipv.it

Husarcek, J.	Nuclear Regulatory Authority, Urad Jadroveho Dozoru SR, Bajkalská 27, 820 07 Bratislava, Slovakia Fax: +421258221166 Email: Jan.Husarcek@ujd.gov.sk
Hutta, J.	Safety Department, Bohunice nuclear power plant, Slovakia Fax: +421335974786 Email: hutta.jozef@ebo.seas.sk
Ibrahim, M.A.	Neutron Physics Department, Nuclear Research Center, Atomic Energy Authority, 129 Omer Ebn El Khattab St., Heliopolise, Cairo, Egypt Email: a_alghazally@hotmail.com
Ivan, F.	National Commission for Nuclear Activities Control, 14 Libertatii Blvd., Sector 5, P.O. Box 42-4, 050706, Bucharest, Romania Fax: +40213373887 Email: florentina.ivan@cncan.ro
Ivanytskyy, V.	National Nuclear Energy Generating Company 3, Vetrova Str. Kyiv 01032, Ukraine Fax: 380442944883 Email: v.ivanytskyy@direkcy.atom.gov.ua
Jackson, A.	Reactor Services Group, AMEC NNC Ltd., Booths Hall, Chelford Road, Knutsford, Cheshire WA 16 8QZ, United Kingdom Fax: +4401565843082 Email: andy.Jackson@nnc.org
Jacobsson, P.	Investigator/Inspector, Swedish Nuclear Power Inspectorate (SKI), Klarabergsniadukten, 10658 Stockholm, Sweden Fax: +4686619086

Kosilov, A.	INIS and Nuclear Knowledge Management Section, Department of Nuclear Energy, International Atomic Energy Agency, Vienna Email: a.kossilov@iaea.org
Lei, W.	Division of Information Technology, International Atomic Energy Agency, Vienna Email: w.lei@iaea.org
Mazour, T.	Nuclear Power Engineering Section, Department of Nuclear Energy, International Atomic Energy Agency, Vienna Email: mazour.t@iaea.org
Over, H.-H.	JRC Petten — European Commission, Institute for Energy, P.O. Box 2, 1755 ZG Petten, Netherlands Fax: +31224565632 Email: hans-helment.over@jrc.nl
Pal, P.	Technical Collaboration Section, Technology Transfer and Collaboration Division, Central Complex, Bhabha Atomic Research Centre, Mumbai 400085, India Fax: +912225505151 Email: preeti@apsara.barc.ernet.in
Pereppadan, N.	Department of Nuclear Energy, International Atomic Energy Agency, Vienna Email: y.pereppadan@iaea.org
Pérez Andraca, L.E.	Planning and Management, Chilean Commission of Nuclear Energy, Amunategui 95, P.O. Box 6500687, Santiago, Chile Fax: +5624702585 Email: leperez@cchen.cl

Petri, M.	Federal Office for Radiation Protection, Arbeits Gruppe Forschungs Koordinierung, Fachgebiet AG1, Post Fach 100149, 38201 Salzgitter, Germany Fax: +49188813331535 Email: mpetri@bfs.de
Pironkov, L.	Kozloduy nuclear power plant, 3321 Kozloduy, Bulgaria Fax: +35997996018 Email: pgpetrov@npp.cit.bg
Rapieh, A.	Malaysian Institute for Nuclear Technology Research (MINT), Bangi, 43000 Kajang, Malaysia Fax: +389253687 Email: rapieh@mint.gov.my
Salimov, M.	Institute of Nuclear Physics, Academy of Science of Uzbekistan, Laboratory of Activation Analysis of Pure Materials, Institute of Nuclear Physics AS RU, 702132, Ulughbek, Tashkent, Uzbekistan Fax: +810998712642590 Email: msalimov@inp.uz
Speranzini, R.A.	General Manager, Candu Technology Development, AECL Chalk River Laboratories, Chalk River, Ontario, Canada Fax: +6135848210 Email: speranzinir@aecl.ca
Sükösd, C.	Budapest University of Technology and Economics, Institute of Nuclear Techniques, 1521 Budapest, P.O. Box 91, Hungary Fax: +3614631954 Email: sukosd@reak.bme.hu

Tiyapun, K.
Office of Atoms for Peace, Bureau of Nuclear Safety Regulation,
16 Vipawadee Ransit Rd., Street Bankean,
Chatucak, 10900 Bangkok, Thailand
Fax: +6625613031
Email: KanokratAor@yahoo.com

Tolstenkov, A.
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna
Email: a.tolstenkov@iaea.org

Tuniz, C.
Abdus Salam International Centre for Theoretical Physics,
Strada Costiera 11,
34014 Trieste, Italy
Email: c.tuniz@ictp.org

Ulfkjaer, L.
Programme and Policy Unit,
Department of Nuclear Safety,
International Atomic Energy Agency,
Vienna
Email: l.ulfkjaer@iaea.org

Vetere, C.L.
Comision Nacional de Energia,
Technology Environment Branch,
Av. Del Libertador 8250,
Ciudad Autonoma De, Buenos Aires, Argentina
Fax: +54011 47041193
Email: vetere@cnea.gov.ar

Workman, R.
INIS and Nuclear Knowledge Management Section,
Department of Nuclear Energy,
International Atomic Energy Agency,
Vienna
Email: R.Workman@iaea.org

Yanagisawa, K.
Japan Atomic Energy Research Institute (JAERI),
1233 Watanuki, Takasaki, Gunma 370-1292, Japan
Fax: +81273472561
Email: yanagisk@popsvr.tokai.jaeri.go.jp

Yanev, Y.	INIS and Nuclear Knowledge Management Section, Department of Nuclear Energy, International Atomic Energy Agency, Vienna Email: y.yanev@iaea.org

The nuclear power and technology sector, comprising the industry, governments and academia, is a knowledge based endeavour similar to other highly technological industries. Recent trends, such as an ageing workforce and declining student enrolment, with the consequent risk of losing accumulated nuclear knowledge and experience, have drawn attention to the need for better management of nuclear knowledge. These proceedings are based on a workshop on managing nuclear knowledge which was jointly organized by the IAEA, the Abdus Salam International Centre for Theoretical Physics and the World Nuclear University. The aim was to increase the awareness of Member States with respect to the challenge of nuclear knowledge management, to share the best practices and to provide a forum for the exchange of information among participating nuclear professionals.

INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA
ISBN 92–0–109406–X
ISSN 0074–1884