LIST OF EXTENDED SYNOPSES

NUCLEAR KNOWLEDGE MANAGEMENT – CHALLENGES AND OPPORTUNITIES

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Knowledge is by far the most important resource in any area of human endeavor. This is particularly true for a complex area such as nuclear technology, which involves virtually every discipline of physical science and engineering. But knowledge, like any other mission-critical resource, needs to be managed carefully.

Clear processes to ensure the relevance, quality, and impact of the knowledge and clear recognition of responsibilities to develop knowledge characterize an effective knowledge management system.

There are three main processes for knowledge management: generation, dissemination, and application. *Generation* includes obtaining information, for example from experiments and experience, interpretation of the information by highly qualified people, and maintaining and updating results. *Dissemination* includes all the mechanisms for passing knowledge to others such as education, publications, and international programs through such organizations as the IAEA and NEA. *Application* is the end use of the knowledge to add value to society.

The knowledge system is also characterized by different risk/time profiles and different responsibilities for each profile. For example, the nuclear industry needs to focus its efforts on relatively short-term goals to ensure that the current nuclear facility operations and designs are viable from a safety and economic point of view. It is extremely important that this focus not be eroded, since the future of nuclear technology depends on how well it is secured for the present. Governments, on the other hand, have the responsibility to develop knowledge generation for longer-term, higher-risk areas that are strategic or pre-commercial. This creates the long-term vision for nuclear technology, which in turn attracts the highly skilled people that the industry needs.

It is important to recognize the different levels of knowledge required for the various nuclear functions. These levels can be classified as *know what*, *know how*, and *know why*. At the *know what* level, there is sufficient knowledge of nuclear technology to know what needs to be done. This level is the minimum required for senior managers who make decisions and allocate resources. At the *know how* level, experts have the technical depth to apply their knowledge to nuclear systems and designs. At the *know why* level, experts have the fundamental understanding of basic phenomena required to generate new knowledge. Each of the three levels of knowledge is required and each has its own set of challenges to maintain.

An additional set of challenges involves the infrastructure required for nuclear knowledge development and maintenance. This infrastructure has always been extensive and includes laboratories capable of handling a variety of nuclear materials, research reactors, hot cells, demonstration facilities, and all the supporting activities such as nuclear operations, health physics, active shops, and licensing. In recent years, the cost of this infrastructure has risen due to such drivers as improved waste management and operations practices, increased security, and evolving regulatory requirements. These trends mean that the only economic means to maintain the infrastructure is through large, centralized facilities that are open to, and serve, all the stakeholders.

All the characteristics discussed above must be taken into consideration for a robust nuclear knowledge management system. Indeed, it is the responsibility of decision-makers to ensure that these characteristics are in place or accessible for the deployment of major nuclear facilities. This presentation provides an overview of these characteristics, and the challenges and opportunities associated with them.

KNOWLEDGE MANAGEMENT - A KEY ISSUE FOR ENBW

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The motivation for knowledge management can be summarised with the words of EnBW CEO Prof. Claassen, 2002 "knowledge manager of the year" in Germany: "Against the backdrop of the ever-increasing complexity of strategic planning and activities on the operational front, knowledge management is a key factor in the long-term success of our business."

Professional knowledge management motivates and supports employees, helping to create networks in which they can lay the foundations for the future success of the company.

It must be emphasised that knowledge management is the responsibility of management, and EnBW has established a suitable framework consisting of different action levels and goals:

- Normative level (corporate culture): creating a knowledge-aware and knowledge-friendly corporate culture
- Strategic level (human resources): systematic gearing of internal intangible potentials towards future requirements.
- Operational level (information/communication): making the required knowledge available in the necessary scope and quality, in the right place and at the right time.

If knowledge management can generally be seen as basic requirement for successful companies, then it is even more important for nuclear operators. Today, nuclear energy is an important generating technology in Europe, for Germany and for EnBW with major future potential, but a technology that must be employed with great caution and attaching top priority to safe operation. For nuclear operators, the rule is always "safety first". But knowledge management implemented and used in the right way can also enhance both safety and competitive operation of the plants at the same time. In this connection, successful knowledge management plays a key role due to the complex interplay of many different disciplines within a demanding legal and regulatory framework, the paramount importance of collective past experience and the high demands on the expertise of the employees operating nuclear power facilities. Competent and motivated employees, a good safety culture, excellent knowledge management and good organised processes create a solid foundation. This is why knowledge management has been consistently and systematically integrated in the EnBW strategy for a number of years now. Examples for the implementation of knowledge management objectives in the nuclear energy operations of EnBW:

- Cascading of corporate goals down to the individual company and clear-cut definition and broadly-based communication of the goals on the level of the nuclear generating company to ensure that employees understand the overall context and the key challenges.
- Far-sighted personnel planning providing for overlaps between outgoing and new incoming employees, measures to promote the willingness to learn etc.

- Human resource management/Maintenance of personnel levels exceeding official requirements.
- Cooperation with other German energy supply companies in the creation of a "nuclear energy expert network" to systematically support and promote the preservation of the nuclear technology infrastructure in the research landscape
- Implementation of a special knowledge management project in connection with the dismantling of the Obrigheim facility.
- Implementation of an indicator-based safety management system at all nuclear power plant locations of EnBW.
- All processes that are key to operation are standardised in the form of a workflow model and documented in an electronic database system; appointment of responsible process officer.
- Strategic and broadly based ageing management programme.
- EnBW's nuclear power plants regularly undergo international reviews.

STRATEGY FOLLOWED BY INDIA IN PROVIDING TRAINED MANPOWER FOR NUCLEAR INDUSTRY

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Abstract

Around the middle of the previous century, nuclear science and engineering was going through a phase of rapid development and no other field came close to it in terms of providing a challenging career. The situation today is different. While the nuclear industry, in its endeavour to provide electricity at affordable prices, offers several technical challenges and thereby attractive career opportunities, but to a young person entering a university or to a young professional choosing a career, these are not the only attractions. To the young, new areas always look more attractive as they seem to provide, in addition to technical challenges, opportunities for faster growth.

Nuclear industry has to devise strategies to attract and train quality manpower to ensure its continued growth. Strategies for training or for inter-generational transfer of knowledge depends on the type of knowledge viz., explicit or tacit. When first developed, knowledge is tacit and it takes time and effort to transform it into explicit knowledge. Conventional education system has been in existence for centuries and has done well for transfer of explicit knowledge in all disciplines including nuclear science and technology. A large body of knowledge in the area of nuclear science and technology is still in tacit form. One has to devise mechanisms for its identification, capture and inter-generational transfer. This can be done only by involving practicing professionals in the process of knowledge transfer. In India, we are following a strategy, which has been successful in attracting young to the nuclear industry and training them for a career in nuclear science and technology. In the recent past, we have taken a major initiative to make a career in nuclear science and technology still more attractive. This paper reviews all the strategies being followed by us in India and the challenges ahead.

A FRAMEWORK FOR KNOWLEDGE MANAGEMENT AT THE US NUCLEAR REGULATORY COMMISSION

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Introduction and Background

The NRC is a knowledge-centric agency that relies on its staff to make the sound regulatory decisions needed to accomplish the agency's mission. In the recent past, the agency has enjoyed a stable workforce and a climate of slowly-evolving technologies that has allowed it to meet its performance goals by using an informal approach to knowledge management (KM). That environment has changed due new conditions including a substantial growth in workload and the agency must now institute a systematic approach to KM that can support the faster rate of knowledge collection, transfer, and use needed to accommodate increased staff retirements, mid-career staff turnovers, the addition of new staff, and the broader scope of knowledge needed to expand the agency's knowledge base to support growth, new technologies and new reactor designs.

Senior managers have identified KM as essential for accomplishing the agency's current and future work. Additionally, while acknowledging that the agency has a long history of informal KM activities, the senior managers determined that our programs need to change in order to keep pace with numerous factors, including the growing body of internal and external information relevant to NRC decisionmaking. Agency programs also need to look at changes in the regulatory environment and adapt innovative solutions to accelerate and improve agency decisionmaking processes through collaboration and best practices of communications and information sharing.

Recent events have created strategic drivers that have increased the imperative for knowledge management. First, the NRC is among the oldest workforce in the federal government and a large percentage of employees are eligible to retire in the next five years. Second, the demand for new talent outstrips the supply, generating a need to create an attractive environment where new and younger employees have a voice in the direction of the agency. Third, the tremendous increase in interest in nuclear energy internationally has fueled the mission of the NRC, which has in turn increased the need to hire more staff, train them, and encourage the transfer of knowledge quickly in order to meet these growing needs.

The agency, since its inception, has maintained and continuously improved the individual capabilities of its staff through numerous methods designed to transfer implicit and tacit knowledge, such as formal classroom and on-the-job training, structured qualification programs, informal communities of practice, mentoring, dual-encumbering of positions, and formal development programs. The agency has also maintained its organizational capabilities or structural knowledge largely in the form of explicit knowledge: job aids and desk references, written policies and procedures, regulatory guides, standard review plans, new regulations, regulatory issues summaries, and statements of consideration for rulemakings. Although Web-based applications and databases support and enhance KM activities, the agency primarily relies on people and not on information technology solutions to transfer knowledge.

MANAGING KNOWLEDGE IN TECHNICAL AND SCIENTIFIC SUPPORT ORGANIZATIONS

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In an introduction, the issues in knowledge management regarding licensing and supervision authorities as well as technical and scientific support organisations (TSO's) will be discussed. Although in general many of these issues are quite similar across organizations in the nuclear field, specific questions arise according to the knowledge management policies in regulation and supervision, as will be demonstrated by discussing the results of a recent workshop on human resource management in regulation and safety.

With the need for managing knowledge in regulation and safety, a further field of supporting authorities has been opened to TSO's. As a prerequisite, a good knowledge on knowledge management methods and tools has to be acquired by a TSO, preferably by installing an own knowledge management system, thus gaining the indispensable practical experience. Driven by the ongoing demographic change, some TSO's have started early with the implementation of knowledge management practices in their own organizations.

Three examples will be presented in the paper concerning knowledge management in safety and regulation, illustrating the efforts undertaken at GRS, the BMU (German Federal Ministery of Environment, Nature Preservation and Reactor Safety), and the TÜV-SÜD.

At GRS, knowledge management started by specifying the goals of maintaining knowledge, particularly of retiring experts, and transferring this knowledge to the next generation. In addition, the knowledge management methods should become an integral part of every day's work, thus ensuring the sustainability of the effort. Initially, a basis for handling and distributing information and documents was provided by setting up a portal with integrated document management capabilities. In a next step, work was concentrated on the core business process, namely project work. This has been achieved by providing an own portal site for each project where all information pertinent to the project such as documents, internal and external links, contacts or events is available. Actually, efforts are under way to establish sites specific to the knowledge domains of GRS, providing good reference on the topics important to these domains and links to relevant and up to date information and documents. Methods have been studied and tested for capturing and representing an expert's knowledge; the results of such efforts may be utilized to enhance existing knowledge domain sites. In addition, the new structure should improve information retrieval by enterprise-wide search.

The experience gained in installing a knowledge management programme has led the BMU to assign projects to GRS with the aim of designing and constructing an information portal for reactor safety (RS), which should serve as a workbench for the staff of the RS department. The portal has been implemented and is currently accessible from within the BMU intranet. For the portal, electronic and conventional compilations of documents and specific information for atomic licensing authorities have been sifted and evaluated. It provides a document management system, which allows collaboration on documents and their exchange, offers information in its proper context (e.g. national and international regulations), mappings of processes as provided by quality management procedures, access to external databases and communication means such as discussion boards. A link to the GRS portal has been established by daily replicating documents and information concerning projects funded by the BMU.

The TÜV SÜD's daily work - licensing and supervision tasks on behalf of the Bavarian State Ministry - covers all aspects of plant safety like inspection and maintenance, evaluation of events, modifications of hardware and operation and several other safety related activities like periodic safety reviews and probabilistic analyses. Since decades, the TÜV has gathered lots of data and consequently gained a large pool of experiences. In former times, these data and experiences were mainly "property" of individual experts with long time expertise in their working area. But since the working "life time" of these experts cannot be prolonged, and the amount and complexity of data grew, accompanied by an increasing amount and fluctuation of staff, tools to manage these problems and to assure that availability of data and transfer of experiences are well organized within TÜV were needed. In order to coordinate the findings gained in supervising and licensing procedures, an information system was developed which supports systematic data collection and evaluation in and across several plants. All data required for integral plant supervision is collected for all Bavarian nuclear power plants, evaluated and presented in a well-structured manner in order to ensure effective use of such information. The data are connected with individual remarks and experiences of the experts who have the task and opportunity to write down important and/or useful additional information. The functionality of the system is increasingly becoming a critical factor where routine processes need to be handled efficiently and fast responses to dangerous occurrences are called for.

THE ROLE OF KNOWLEDGE MANAGEMENT IN ACHIEVING HARMONIZED HIGH LEVEL OF NUCLEAR SAFETY

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The challenge for governments in the nuclear safety regulatory area is to maintain high standards of safety while ensuring that regulation is effective and focused on real risks. We speak more and more about the need for harmonization, one of the reasons probably is that the context in which nuclear regulators work has changed. Protecting citizens and the environment is a more demanding task in the 21st century. Nuclear operators must perform more efficiently and be more innovative in a highly integrated international economy. Perhaps not surprisingly, regulators can hear from the industry that the current regulatory system often acts as a constraint to innovation, competitiveness, investment and trade.

Regulatory oversight was earlier very much connected to inspection and review of the technical solutions presented for various purposes. Today it is instead an outspoken strategy by many regulators to move more towards inspection and reviewing of the work processes by which nuclear power plants themselves ensure that their safety management activities are covering and efficient. The concept of risk informed regulation has also been associated to an allocation of resources for regulatory activities, which is governed by their importance for safety.

The enlarged EU is the world's leading nuclear electricity generator. Development in regulatory approaches and priorities due to changing economic conditions to produce electricity, ageing and modernization of existing reactors and due to human assets takes place in countries with nuclear power. The EURATOM Treaty calls for the establishment of "uniform safety standards" in the EU, at the same time, the sovereign power of national governments to manage their energy sectors is affirmed. A compromise must be found which maintains the highest safety standards for EU citizens, but respects these two positions.

The nuclear safety regulatory requirements are always anchored in the national legislation, because they imply the exercise of authority in the case a utility fails to live up to the requirements. However, the member states of EU have much to be gained from harmonization of national approaches.

The objective of WENRA harmonization work is to achieve step by step the level of convergence warranting that "there are no substantial differences between the countries from the safety point of view in generic formally issued national safety requirements, and in the resulting implementation on the nuclear power plants".

Harmonization means neither uniformity nor loss of responsibility. It means, for instance, that a improvement that has been discovered in one place can be more easily made universal. Harmonization is a prerequisite for sharing a certain number of tasks, rather than reinventing them in every institution involved. Harmonization would thus enable all actors to more easily achieve the standards of those with the best ones.

The goals for the interface between regulatory and industry oversight activities also need to be considered. Perhaps an ideal world would rely on nuclear industry self-regulation with regulatory oversight to assure itself and the public that the self-regulation is working. This requires also a better understanding of how the social environment influences both nuclear industry safety performance and regulatory oversight activities.

Knowledge management is important for enhancing an organization's ability and capacity to deal with its mission, its ability to deliver the results and to be able to cope with change.

The value of knowledge management relates directly to the effectiveness with which the managed knowledge enables the members of the organization to deal with today's situations and effectively envision and create their future. Without access to managed knowledge, every situation is addressed based on what the individual or group brings to the situation with them. With access to managed knowledge, every situation is addressed with the sum total of everything anyone in the organization has ever learned about a situation of a similar nature.

Regulators, like most other organizations in the nuclear field, face the challenge of capturing and managing its nuclear knowledge due to an ageing workforce. There is now a generation shift. This means that many people who are well aware of what is said in safety legislation, standards and recommendation are less conscious of why it is said. For addressing this challenge we need tools for transferring data into information, information into knowledge and knowledge into wisdom.

KNOWLEDGE MANAGEMENT IN THE JAPANESE HIGH-LEVEL WASTE DISPOSAL PROGRAMME

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The importance of nuclear power as a major source of sustainable energy is now gaining recognition worldwide in the light of increasing concern about the longevity of oil and gas reserves and, especially, global climate change due to carbon dioxide emissions resulting from the use of fossil fuels. In order to demonstrate that nuclear energy is truly sustainable, we need to make progress on the disposal of high-level radioactive waste (HLW) and, in this area, increasing investment of effort has been seen during the past decade in various parts of the world.

HLW disposal projects are unique in terms of their duration, complexity and political sensitivity. Even after 3 decades of generic planning, implementation of the first Japanese HLW repository, starting from initial site investigations through to the closure of the filled-up repository, could run until the end of this century. Even after the closure of repository, post-closure monitoring may follow for an even longer period.

In the course of executing such a long-term project, the quantity of data, information, understanding and experience (generally termed "knowledge) that is accumulated is truly vast. This results from the breadth of required multidisciplinary knowledge, which is wider than almost any other industry - covering technical areas from geology to radiation physics, materials science to microbiology, archaeology to engineering; but also social and ethical aspects, relating to activities such as public communication, policy-making and legislation. With the exponential growth in the rate at which knowledge is being produced, it is clear that an efficient Knowledge Management System (KMS) is critical to coordinate and implement such a programme.

A further critical boundary condition in Japan involves the decision to initiate site selection with a call for volunteers, and then proceed in a stepwise and iterative manner. Information accumulated on different sites needs to be re-evaluated at various stages to form the basis for site-selection decisions, which have to be made in an open and transparent manner. Maintaining and updating such an extensive knowledge base – and communicating appropriate information to all relevant stakeholders – is clearly beyond the capabilities of conventional KM approaches and hence establishment of novel methodology, based on modern, state-of-art information technology, is seen to be necessary.

This paper describes the current status of knowledge management activities in the Japanese high-level waste disposal programme and provides a perspective on some of the ambitious developments in this field planned for the future.

THE LOSS OF KNOWLEDGE IN NUCLEAR SAFETY AND RADIATION PROTECTION DURING THE SPANISH NUCLEAR MORATORIUM

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The life of a nuclear power plant includes seven phases: site selection and characterization, design and construction, commissioning, operation, decommissioning, dismantling and long term spent fuel management, comprising about 100 years and at least three generations of workers. Each one of these phases requires specific knowledge and experience, which has to be managed along the life of the nuclear energy deployment in any country. When such deployment is interrupted and later on resumed, as in Spain, the knowledge and experience gained during the first phase could only be effectively transferred to the new phase if a proper knowledge management was implemented, which was nor normally the case in the early days. The knowledge gained is certainly in the files and archives for everybody to read, but it can only be read effectively by those who have participated in creating the knowledge. The experience is lost with the people.

The Spanish nuclear power programme started in the decade of the 60´s. By early 1980, seven plants were in operation and seven more under different stages of construction. There was a great deal of optimism, the participation of the domestic industry was encouraged and growing, and there was research and development in the national research laboratories and the universities. The industry provided heavy and all type of components, fuel fabrication was also national, the whole fuel cycle was given attention, architect-engineering and servicing companies were also created. A regulatory organization was born, legislation was enacted and nuclear activities were under proper regulatory control. Nevertheless, in 1983 the Authorities decided to stop all this progress, the construction authorization for five of the seven plants was cancelled, a moratorium on the construction of new plants was enacted and the fuel cycle was declared open. This created a great impact on the new industry, nuclear activities declined in all senses, and pessimism on nuclear started to grow. A new more independent regulatory organization was created. At present, there are seven nuclear power plants in operation and two are been dismantled. Future prospect for new plants are very dim at the moment.

As nuclear power should not be completely discarded, it is of interest to evaluate the knowledge and experience lost, in both the industry and the regulatory body, to see whether or not it could be recuperated and to establish conditions for a potential nuclear renewal. The knowledge and experience gained during the three first phases: site selection and characterization, design and construction and commissioning, are practically lost and difficult to recuperate. The last phases: operation, decommissioning, dismantling and long term spent fuel management are on-going activities.

Site selection and characterization was very active in the 60´s and 70´s. Many applications for site permits were filed. Individual site studies were performed as well as studies performed by the regulatory authority on the potential nuclear capacity of some river basins and coastal regions. Practically all participants in such studies are retired and the experience gained is lost. The analysis of external events for probabilistic safety studies has brought back some valuable experience, but it only refers to existing sites. Finding new sites for a new substantial renewal of nuclear power will be a difficult job for the utilities. This activity will have to commence anew.

Design and construction is a major endeavour. Spain is termed as a qualified importer, in the sense that the domestic industry participates in the design and construction of the imported plants. Only the first unit was a turn-key contract. The participation of the Spanish industry, mainly in the balance of plant, structures and ancillary systems was intense. Quality assurance and quality control were the responsibility of the plant owner. The regulatory organization also developed a great deal of experience in regulating design and construction and in verifying compliance with regulations, that were also growing. The last construction activities ended in 1986. Since that time, the activities of the regulatory body and national industry were limited to implement modifications in the domestic plants. The new regulatory authority has yet to issue the first construction authorization. A new built will not profit much from the old experience.

Commissioning is the phase when the interchange of knowledge between the supplier and the utility is more intense and under the supervision of the regulatory authority. The utility has been preparing during the four or five previous years the new operating personnel. A number of pre-nuclear and nuclear tests, up to the final acceptance test, are performed in collaboration between the experienced provider and the new operating team. The last activity of this type took place in Spain in 1986-87. The original people who participated in the transfer of such knowledge are now out of operation and replaced by new operating personnel who have not seen that previous experience. The same applies to the regulatory body. Future deployment of nuclear energy may encounter difficulties in finding experts on that matter on both sides, the supplier and the receiver of the plant, as well as on the regulatory body.

As the last phases are on-going activities, it is of interest to create methodology and procedures to manage knowledge acquired in operation, decommissioning, dismantling and spent fuel management. The Spanish utilities and the national radioactive waste company are creating procedures to secure such knowledge and experience following the IAEA recommendations. The regulatory authority has recently issued an Instruction to maintain knowledge and experience on radiation protection matters. More Instructions may follow.

IMPLEMENTING KNOWLEDGE MANAGEMENT AT THE SWISS NUCLEAR SAFETY INSPECTORATE (HSK)

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The Swiss Nuclear Safety Inspectorate (HSK) currently faces a generation change. In the years 2005 to 2007 up to 15 retirements of experienced experts are anticipated. Within only three years HSK will have to replace one third of its management and will at the same time loose valuable know-how. Experience has taught us that it becomes increasingly difficult to replace the leaving employees by qualified specialists. Consequently recruitment and training of new staff members becomes more time-consuming and expensive.

HSK considers knowledge management to be a valuable tool in order to cope with this change. Therefore a concept has been developed, which evaluates the existing or planned elements of knowledge management considering the amount of work, the benefit and the feasibility and combining them to an efficient system. By doing so HSK encountered two specific problems:

- Generally there is rather too much information than too little within an organization. However the information available is not in the required form. Much knowledge is stored unstructured in the offices of the experts and can therefore only be accessed with their aid. Since it is very expensive to compile and collate any unstructured information, it is absolutely important to identify the valuable knowledge of the organization. One must permanently assure that the necessary knowledge is present and that information no longer required is removed from the system.
- Knowledge is not only explicit. A large portion of knowledge is tacit in the heads of the employees. It is very difficult to convert this tacit knowledge into an explicit form. It can therefore not be processed electronically not even with the best data base systems and search engines. In this context, technology is important but technology alone can not resolve every problem. Personnel development is just as important. Ways must be found to pass on tacit knowledge within the staff.

With its management system [1] HSK possesses a powerful tool to handle the first problem. Knowledge management is integrated into this system. The specific implementation is based on two control cycles inspired by the “Deming wheel” (see FIG. 1.). The Deming wheel is one of the most popular tools to support continuous improvement. It focuses the efforts around the four steps PLAN, DO, CHECK, and ACT.

The high-level, strategic cycle ensures that all competences are available which are necessary to deal with HSK’s regulatory and technical responsibilities. The main outputs of the strategic cycle are knowledge objectives for the different fields of application. The subordinate cycle covers the operational aspects. It is used in various fields of application and therefore exists in several versions. The knowledge objectives as defined by the strategic cycle serve as input for the operative cycle and link them to each other.

There are several theoretical approaches to transform the tacit knowledge of the employees into explicit knowledge. HSK tried to implement this knowledge transfer by means of structured interviews, but the attempt was not very promising [2]. The findings and benefits were not in proportion to the investment of money and mainly of time, and the project was finally cancelled.

Today HSK consequently invests in human resource development activities. The goal is to keep the tacit knowledge by promoted teamwork and by systematic and consequent training and further education. Explicit knowledge is collected and documented according to the rules laid out in the management system and is available to everybody through different tools basing on a sophisticated document management system.

In this paper the implementation of the knowledge management system at HSK is illustrated by the way of two representative examples, highlighting the elements and content of the different control cycles.

FIG. 1. Knowledge management control cycles

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FROM NUCLEAR STAGNATION TO RENAISSANCE: THE CHALLENGE OF TRANSFERRING REGULATORY KNOWLEDGE

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Around 20 years ago there was a *de facto* nuclear stagnation of the peaceful uses of atomic energy in the West. At the time, governmental institutions for nuclear research and regulation, as well as the nuclear industry, had a nuclear “intelligentsia” and many well qualified specialists available. Moreover, universities were ready and able to educate the next generation of professionals. The decline of the nuclear industry was therefore damaging both for individuals and the schools educating them. The options were few: for the workers, to restart a working life in other industries or to try to hang on until retirement; for the educational institutions, to abandon researching and teaching nuclear subjects.

Now, however, an emerging energy crisis and growing environmental concerns about the burning of fossil fuels are inducing Western politicians to rethink the soundness of the decision to curtail the nuclear power industry. It therefore seems that there will be a nuclear renaissance, but that the qualified personnel to carry this out are no longer available, since in the intervening years they have changed jobs, retired or died. Put simply, the plentiful workforce responsible for last century’s nuclear miracle is no longer there. Moreover, a cultural gap exists between the past and present generations, and such a lack of cultural continuity creates a difficult challenge for the traditional inter-generational knowledge transfer that has enabled development in the past.

There are many reasons for this situation, and it will be for historians to explain them, but it is obvious that the Chernobyl accident and the public belief that nuclear installations were not safely regulated played a crucial role. At the time, nuclear regulatory authorities were less demanding, and in many countries they simply did not exist. Concepts such as regulatory independence and strengthening and safety culture are generally post-Chernobyl phenomena. Moreover, over the past decades a significant development has occurred in both the epistemology of radiation exposure and its health effects and on the radiation safety paradigm. It seems therefore that the new situation creates particular problems for knowledge transfer in nuclear regulatory authorities, even more perhaps than in the industry itself.

The paper analyses the challenges of knowledge transfer and management that a nuclear renaissance will pose to regulatory authorities worldwide. The particular situation in the author’s country, Argentina, which was one of the first Western countries to formally declare a rebirth of the nuclear industry, is presented as an example of the mammoth effort that will be required to restore regulatory knowledge on the scale needed for a revitalized nuclear programme. Finally, a synthesis is presented on the possible ways forward, including international actions that could ameliorate the situation.

PERSPECTIVES OF DEVELOPING AND USING OF KNOWLEDGE BASE ON NPP'S I&C FOR EXPERT ACTIVITY SUPPORT

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The development of knowledge base is very essential in field of NPP's I&C because of high rate of progress in hardware and software technologies, wide-ranging modernization of I&C concerned with this progress and existence and regular renovation of large amount of different standards and regulations concerning to I&C systems and their components.

Experts have to work with large amount of different information during the analysis and assessment of documents, which substantiate safety under NPP's I&C implementation (modernization). In addition to analysis of documents, which was sent on expertise, specialists also have to:

- assess different substantiating and additional documents of designers and NPP's;
- obtain as much as possible complete information about implemented (modernized) I&C;
- get the information about results of expert reviews, which were fulfilled before;
- choose the methods of assessment;
- work with different standards, guides and rules;
- assess the compliance of assessed document with large amount of regulatory requirements to NPP's I&C safety;
- use national and international publications in field of I&C.

High quality of NPP's I&C analysis and assessment is ensure thanks to such complex and comprehensive approach.

It is obvious that such approach requires the effective information support of expert activity. Therefore development of knowledge base on NPP's I&C for expert organizations (such as State Scientific-Technical Center on Nuclear and Radiation Safety – SSTC NRS) is very actual and important task. This knowledge base will allow to regulate the information flows in enterprise, to organize common centralized and neatly structured data warehouse and to make easier the searching of necessary information for the work. It means that effectiveness of work and quality of expert reviews will be raised.

It is necessary to note that using of knowledge base is not confined only the carrying out of expert reviews (although it is most important task). Knowledge base could be used also for help in current work (elaboration of standards, support of NPP, fulfillment of research scientific work, international collaboration, preparing of publication and so on) and for transfer knowledge and experience to young specialists.

Actually, proposed knowledge base of SSTC NRS will be the complex of databases and other information sources (documents in electronic and printed view, compact disks and so on) with common software shell, which allow quickly to find and to get complete, authentic, well-ordered and structured data, which are contained in different information sources. Such structuring is intended to ensure the maximum complete end easy searching of necessary information and to formalize the expertise process in SSTC NRS.

Common structure of NPP's I&C knowledge base is presented in Fig. 1. Proposed internal structure of each mentioned knowledge base components [1] is determined on the base of experience in safety regulation and assessment and is approbate during developing and practical using this knowledge base by experts.

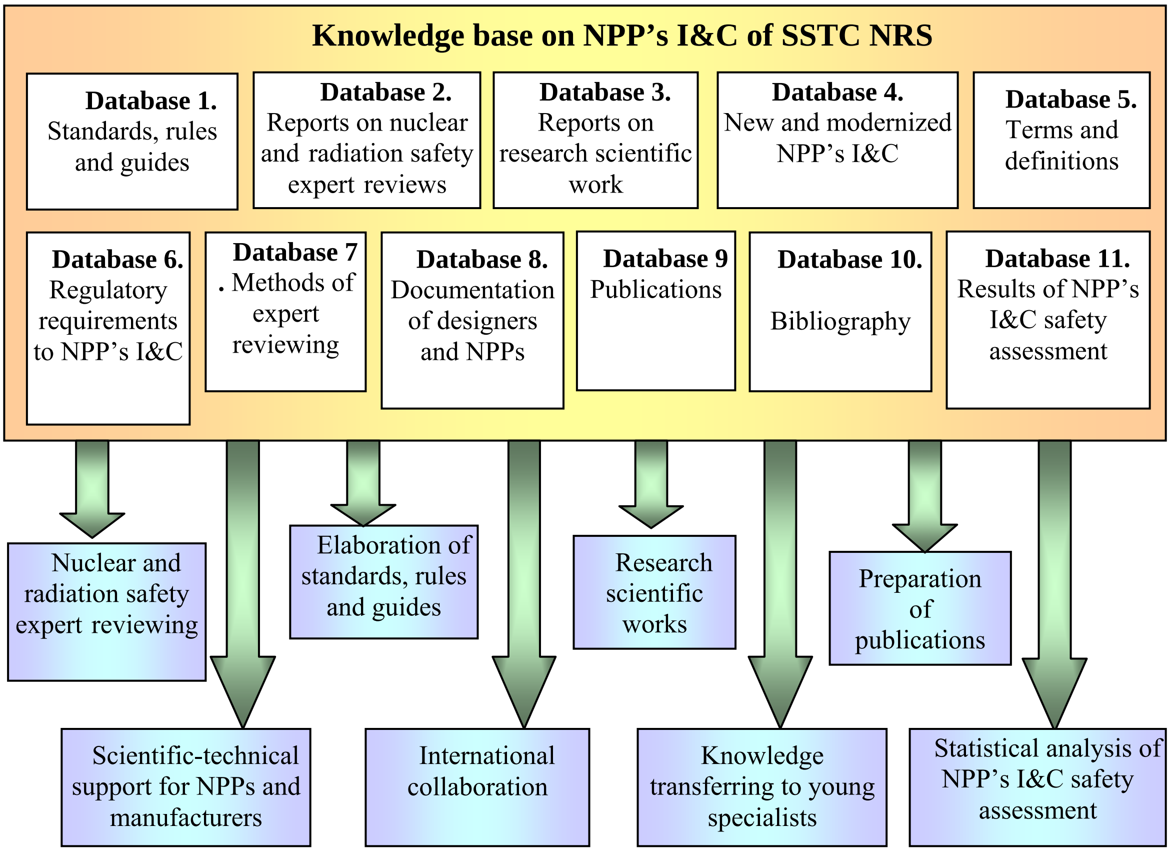

FIG. 1. Common structure of NPP's I&C knowledge base, which is developing in SSTC NRS

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CHALLENGES TO IMPLEMENTATION OF KNOWLEDGE MANAGEMENT ON DRAFTING OF NUCLEAR REGULATION IN INDONESIA

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Although Indonesia still reviewing its nuclear power options, in anticipation of the possible introduction of a NPP in the near future, and in order to contribute to the global nuclear safety culture, the Indonesia Government enacted, on 10 April 1997, Act No. 10 of 1997 on Nuclear Energy.

With reference to Article 14 of Act No 10 of 1997, BAPETEN (Nuclear Energy Regulatory Agency) is empowered to control on the use of any nuclear energy utilization through regulations, licensing, and inspections. In conducting its tasks, as one of non departmental government agencies, BAPETEN is under and directly responsible to the President of Republic of Indonesia Pursuant to Presidential Decree No 103 year 2001 on Status, Function, Authority, Form and Organization Structure of Non-Departmental Government Agencies.

The basic principles of nuclear energy regulate on practice in Indonesia set out in the law provide that control of any nuclear energy application is aimed to: [1]

a. Assure the welfare, the security and the peace of people;

b. Assure the safety and the health of workers and public, and the environmental protection;

c. Maintain the legal order in implementing the use of nuclear energy;

d. Increase the legal awareness of nuclear energy user to develop a safety culture in nuclear field;

e. Prevent the diversion of the purpose of the nuclear material utilization; and

f. Assure for maintaining and increasing the worker discipline on the implementation of nuclear energy utilization.

Nuclear energy act enacted in 10 April 1997 and promulgated in state Gazette of Republic Indonesia Year 1997 No 23 Supplementary Gazette 36765 contains of elucidation thereto is the principal and primary law governing all related aspects in the use of nuclear energy i.e. institutions, research and development, exploration, regulatory authority, radioactive waste management, liability for nuclear damage and penal provisions. In order to implement the act comprehensively requires more detailed, technical, practicable and explainable regulations that become its secondary and derivatives regulations, which include government Regulations, Presidential decree and Chairman Decree.

Challenges of Nuclear Regulation in Indonesia

1. Introduction of NPP, Development of regulatory instruments (standard, licensing and inspection systems)
2. Radiation Safety & Radiological Protection,
3. Nuclear and Radiological Security,
4. Ageing Nuclear Installations,

5. Globalization of Nuclear Business.

In development of the nuclear regulation, BAPETEN implement knowledge management to collect regulation list which must be made, evaluating content, classifying according to regulation hierarchy, integrating of regulation which is one with other, knowledge sharing.

Complicated knowledge transfer to implementation of knowledge management in the nuclear regulation development context can include: lack of leadership commitment, cultural barriers, lack of trust, information overload and isolation, etc.

Knowledge Management Harrod's (2000) defines KM as "The process of collecting, organizing, storing and exploiting the information and data that is held within an organization, particularly information known to individuals (tacit knowledge), as well as the general store of known information and data (explicit knowledge). [4]

One way of viewing tacit knowledge is to see it as the glue that is binding the explicit knowledge together. Another way to describe it, is as "**know-how**", as opposed to: "know-what" (facts), or "know-why" (science), as authorities, "know who.

The evolution of data to knowledge is a multi step process. An organization must first understand the data it holds: Where are the data? What is their quality (e.g., how reliable, how accurate)? How are they managed? What is their content? Secondly, the data must be organized in some schema to make them more accessible, such as documenting the characteristics and quality of the data, developing mechanisms to share data across divisions, categorizing data, structuring data for searches, and establishing relationships among different sets of data.

Development phase of nuclear regulation in Indonesia:

I. Preparation Phase

II. Discussion Phase

III. Decree Phase

Knowledge transfer in the fields of organizational development and organizational learning, is the practical problem of getting a packet of knowledge from one part of the organization to another (or all other) parts of the organization

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MANAGEMENT OF REGISTRATION NUCLEAR SAFETY ENGINEER OF CHINA

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At present, there are altogether 10 nuclear power units in operation in China. In the following decade, China will build about thirty 1,000 MW units to reach an installed capacity of 40,000 MW in 2020; meanwhile, we will also witness great development in the areas of radiation protection, radiation monitoring and nuclear technology application. Thus, the problem of shortage of qualified nuclear safety personnel has arisen. Nuclear safety is closely related to the vital interests of the public and environmental safety; and in range with pollution control and ecological environment protection, nuclear safety has become one of the three key work fields in the environmental protection system in China. In such circumstances, China began in 2003 to implement registered nuclear safety engineer qualification system. By the end of 2006, three examinations had been successfully launched and a total of 395 people have obtained registered nuclear safety engineer qualification.

I. Background of the registration system of nuclear safety engineer qualification.

1. China carries out the registered nuclear safety engineer qualification system is to improve the quality of professional and technical nuclear safety personnel, to regulate the management of key positions in nuclear safety industry, to build a contingent of nuclear safety engineers with professional knowledge and practical capability who also have a comprehensive grasp of nuclear safety regulations and will practice strictly in accordance with the law, and so as to ensure nuclear and radiation safety and to safeguard national interests and public interests.

2. In accordance with the *Regulations on Vocational Qualification Certification* issued by Ministry of Labor of People’s Republic of China and Ministry of Personnel of the People’s Republic of China, the registered qualification system is applicable to professionals who are engaged in key positions related to nuclear safety in work units that provide technical support for nuclear safety and application of nuclear energy and nuclear technology; and this qualification system has been incorporated into the Vocational Qualification Certification System for national professional technician in China and is under unified planning and management by the State. Registered Nuclear Safety Engineer refers to those professionals who are engaged in technical work related to nuclear safety and have passed the national examination to be awarded the *Qualification Certificate of Nuclear Safety Engineer of the People’s Republic of China* and have been registered.

3. In accordance with the *Environmental Protection Law of The People’s Republic of China* and *Act of Protection and Remedy of Radioactive Contamination of the People’s Republic of China*, China has set up a qualification management system for professionals who are engaged in the protection and remedy of radioactive contamination; and has also established a qualification management system for institutions that are engaged in environmental monitoring of radioactive contamination. These

provide legal support for the registered nuclear safety engineer qualification system.

II. The practice scope and responsibility of registered nuclear safety engineer

The practice scope of the nuclear safety engineer is: nuclear safety review, nuclear safety inspection, control and operation of nuclear facilities for civilian-use, nuclear quality assurance, radiation protection, environmental radiation monitoring and other relevant working fields closely related to nuclear safety prescribed by State Environmental Protection Administration.

Nuclear safety engineers must abide by national laws and regulations, and industry codes for practice of nuclear safety; have occupational ethics and professional skills; take responsibility for assuring the authenticity and legitimacy of their profession. Nuclear safety engineers have the right to pursue key positions as technical professionals according to law, and are responsible for their own work. Nuclear safety engineers will be constantly updating their knowledge, voluntarily receive continued education and participate in professional training according to relevant provisions. Nuclear safety engineers should be engaged in and practice in a professional nuclear safety work unit.

III. Administration of registered nuclear safety engineers

The State Environmental Protection Administration set up the division of "Nuclear Safety Engineer Registered Qualification Office" in June, 2003 for the administration of registered nuclear safety engineers. As the regulatory agency, its main responsibilities are as follows:

1. To develop and compile the examination subjects, examination outline and test questions for the nuclear safety engineer examination; to review the qualification of attendees; to arrange scoring; and to bring forward scoring criteria and set up the passing grade.
2. To be responsible for the establishment and administration of the item pool system of the nuclear safety engineer examination.
4. To undertake the registration of nuclear safety engineer (including change of registration) and to issue the certificates.
5. To establish a registration and management system for nuclear safety engineer qualification information, to regularly publish the information of the registration and cancellation of nuclear safety engineers, and to make statistical analysis of registration information.

IV. The registered nuclear safety engineer examination

Unified outline, test questions and organization are adopted in the registered nuclear safety engineer qualification examination. It is implemented together by the Ministry of Personnel of the People's Republic of China and The State Environmental Protection Administration and is held once a year. Whoever complies with China's Constitution, laws and regulations, with professional ethics and meets the requirements can attend the registered nuclear safety engineer examination. The time limit for taking the exam is two years. Literally, the candidates must pass all the four courses required in two consecutive years. Those exempted from some of the tests must pass the other courses required in one year time. The qualified testers will be awarded the *Qualification Certificate of Nuclear Safety Engineer of the People's Republic of China*, which is efficient nationwide. The required test courses are: *Laws and Regulations on Nuclear Safety, Comprehensive Knowledge about Nuclear Safety, Professional Practice of Nuclear Safety,* and *the Analytical Study of Nuclear Safety Cases.*

Laws and Regulations on Nuclear Safety is to test how well testers have comprehended the knowledge of China's laws, regulations and international convention on Nuclear Safety and to arouse consciousness and better understanding of laws and regulations among test-takers.

Comprehensive Knowledge about Nuclear Safety, is to test the knowledge of nuclear physics, nuclear power and nuclear technology application, radiation protection , efflux and environmental radioactivity monitoring, the concept of nuclear and radiation safety, and safety awareness, and to examine the required knowledge as a whole and the ability to apply it in real situations.

Professional Practice of Nuclear Safety, is to test the professional skills, which include: reactor engineering, uranium (thorium) mineral and mineral with concomitant radioactivity, nuclear fuel processing and disposal, and safety transportation of radioactive substance, nuclear technology application, radioactive waste management, decommissioning of nuclear facilities, siting of nuclear facilities, and quality guarantee; which is to improve the test-takers' competence in problem solving.

The Analytical Study of Nuclear Safety Cases is to test test-takers' ability of problem solving based on cases over the knowledge required in the above three specific tests. Through analysis of typical nuclear safety cases and solution formation, we can develop the test-takers' overall practice capacities.

V. The registration of nuclear safety engineer

The title of registered nuclear safety engineer can only be acquired through the registration system. Those who get *Qualification Certificate of Nuclear Safety Engineer of the People's Republic of China* must register before carrying out work under this title. The period of validity is two years. Nuclear Safety Engineer Registered Qualification Office of State Environmental Protection Administration of People's Republic of China is the administration institute for registration. The candidate for registration must get *Qualification Certificate of Nuclear Safety Engineer of the People's Republic of China*, be in good health, be competence for professional post, and gain approval from the inward. Those who apply for re-registration must provide proof of further-training and graduate besides the conditions mentioned above.

VI. Further-education of registered nuclear safety engineer

Further education is required by registered nuclear safety engineer system. The goal of further-training is to update their information, improve their professional knowledge to cope with problems in an analytical and innovative way. The main focus of the training is on the criterion, regulations, technology development of nuclear safety and practical requirement of specific positions. Registered nuclear safety engineer should take further-training voluntarily. Within the validity date (that is within two years), the accumulated hours of further-training should be no less than 40 class hours, the in-class performance and the result of examine will be considered as requisite in re-registration.

The registered nuclear safety engineer qualification system is a new personnel qualification management system as well as a necessary admittance system which provides a platform for the candidate to the key post of nuclear safety industry. The management of registered nuclear safety engineer focuses on candidate's practical ability. Those qualified in the exam will get the certificate. And then, double check the people with certificate during the registration, to ensure that they have outstanding achievement in their work and have attended training program required. Thus, the implementation of registered nuclear safety engineer qualification system bears pragmatic significant to the improvement of the nation's nuclear safety supervision capacity and nuclear safety personnel's techniques.

RECORDS/KNOWLEDGE MANAGEMENT IN A NUCLEAR FACILITY'S INDUSTRIAL HYGIENE LABORATORY

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Los Alamos National Laboratory (LANL) is operated under the USA's Department of Energy (DOE) and is tasked with developing and applying science and technology to ensure the safety and reliability of U.S. nuclear deterrents and solving national problems in defense, energy, environment, and infrastructure. LANL is divided into numerous groups that accomplish various aspects of these overarching goals. An important aspect of this work is to ensure worker safety. To do this LANL has an on-site Industrial Hygiene (IH) Laboratory that is certified by the American Industrial Hygiene Association (AIHA) that follows International Standard ISO/IEC 17025:2005 guidelines. Following these guidelines facilitates appropriate records retention and knowledge management by the laboratory.

Field Industrial Hygienists monitor workers for exposure and generate various swipe and personal breathing zone air samples that are analyzed by the IH Laboratory. The laboratory provides legally defensible data on which health, safety, and environmental decisions are based. Such documentation serves to protect the legal and financial rights of the Laboratory and individuals affected by Laboratory activities. The proper maintenance and filing of this documentation also serves to avoid expensive and unnecessary re-sampling and reanalysis if customers lose reports or if results are requested by regulatory agencies.

We will explain how the Sample Management Office (SMO) interacts with customers to determine their needs to ensure the appropriate analyses are conducted. Additionally, we will explain our process of sample receipt, sample log in into databases, sample analysis, data validation, and compliance to internal procedures, LANL policies, and DOE regulations. Furthermore, we will outline how the Records Management Custodian processes the laboratory's completed data packages starting from database entry to archival at the Federal Records Center.

Many DOE records relating to personnel exposures, contamination, waste, and environmental sampling are kept and are scheduled for long-term retention by National Archives and Records Administration (NARA). Records shall include information created and received in the course of conducting Laboratory programs and business. Records management serves to promote the creation, capture, use, and transfer of records and knowledge. It also serves to preserve and protect the Laboratory's archival of historical documents and information. All records are given retention periods of at least 75 years. After outlining some of our various records and documents, we will explain how our records management and document control systems are set up to ensure effective and efficient retrieval of these records for 75 years.

In conclusion, we will demonstrate how our and LANL's Records Management Program follows good business practices to ensure the protection of our corporate information assets.

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MPC&A CULTURE PROGRAM IN KI RRC

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At the end of 2001 the U.S. DOE initiated a new Russian – American Project “Culture of Nuclear Material Accounting, Control and Physical Protection in Russia” that was funded and implemented through Brookhaven National Laboratory. The goal of the Project was to help Russian nuclear enterprises to achieve a high culture level in the nuclear material management and, as a result, to minimize the risk of various human-factor-related threats against the nuclear material security.

An interagency working group was established to coordinate the project-related initiatives. Since 2004 the working group has selected 9 Russian nuclear sites for the implementation of the experimental program to validate the effectiveness of the “MPC&A Culture” Project. The list of the enterprises included the KI RRC. The enterprises appointed “Culture coordinators” who were professional specialists in the improvement of the MPC&A culture at the site.

The regular workshops of the working group members and culture coordinators have demonstrated the effectiveness of this structure in the enhancement of the MPC&A culture at these sites, and now the expansion of the project to cover other Russian nuclear sites is being discussed.

The KI RRC has been intensively involved in the improvement of the MPC&A culture. The Center has established a working group headed by a Deputy Director of the KI RRC. The working group carries out activities aimed at a reduction of conscious and accidental errors by the Center personnel in MPC&A area.

One of the works in this area is the conduct of analytical studies of violations of the discipline, procedures and instructions in the nuclear material management, which resulted in Rostechnadzor charges at one of the KI RRC facilities over the last three years during the Gosatomnadzor training inspections (now Rostechnadzor). A result of this work is to analyze the percentage of the MPC&A culture violations relative the general number of the revealed violations. Moreover the analysis should contribute to the development of recommendations to minimize the number of violations by the enhancement of the nuclear material MPC&A culture at this facility.

Another interesting work is the development of the MPC&A Culture Enhancement Concept at our site.

The Paper also describes other KI RRC activities in this area, their results and conclusions on the practicability of continuing the work in this area.

KNOWLEDGE PRESERVATION FOR SUCCESSFUL DEVELOPMENT OF NUCLEAR POWER (USING THE BEST PRACTICE OF RESEARCH AND TECHNOLOGICAL AGENCY "NON-PROLIFERATION" IN STRUCTURE OF FEDERAL STATE INSTITUTION RUSSIAN RESEARCH CENTER "KURCHATOV INSTITUTE")

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The great demand for electricity is expected in the nearest future particularly in developing countries. This demand is caused by great population grows that is happening now especially in the developing world. The demand for electricity will affect the demand for energy carries correspondingly.

There are some burning questions such as the prospective scantiness of fossil fuels, issue of future energy supply (as a consequence of scantiness of fossil fuels), issue of global worming and issue of carbon dioxide emission, waste recovery of hydrocarbon fuel production that helps the world stakeholders to look up towards the nuclear energy.

Skilful handling with nuclear energy will help to solve the above mentioned issues of future and let the nuclear renascence be the reality not only the words.

The atomic industry wasn’t developed widely [was in a shadow] during the last years. It took place not only in Russia but in other countries that has nuclear industry. The wide-ranging development of nuclear energetic was stopped after Chernobyl accident in 1986. Now we are leaving in the era of nuclear renascence that can be proofed by announcements of some world leaders like the US President Gorge Bush, Russia President Vladimir Putin, UK Prime Minister Tony Blair and others.

The one of the consequences of being “in the shadow” for nuclear industry after Chernobyl accident and people’s fear for nuclear was that young generation of people wasn’t consider the nuclear industry like a perspective and modern industry. It should be said that modern and perspective things mean a lot for young generation. Because of that the number of students in universities for nuclear majors decreased dramatically. And so the number of young specialists and engineers that entered the industry decreased.

In Russia and some other former Soviet Union countries the satiation was worsen by the economic situation after Soviet Union collapse i.e. salary of engineers, scientific workers, professors dipped below living wage. This is why not only the number of students in universities decreased but professors’ stuff in universities and industry’s stuff dramatically decreased.

For successful development of nuclear power we need resources i.e. people, knowledge and desire for effective actions (beside positive political solutions that is not considered in this paper). Except for the lack of the young professionals there is a big gap in a number of middle-aged specialists at the industry and at the universities’ stuff today. Thus the issue of knowledge preserving and knowledge transition from the old generation of specialists that are closed to retiring to the young employees has come up recently. Taking into account nuclear renaissance this issue is a very burning question.

The process of successful transmission of knowledge from the old generation to young one trough the increasing the interest of young generation to nuclear industry and fir their job is considered in this paper. Some examples of achievement of increasing of professionals interests through participation in conferences, seminars, training and social activities are given.

Also this paper describes the positive practice of Research and Technological Agency “Nonproliferation” is in structure of Federal State Institution Russian Research Center “Kurchatov Institute” in nuclear knowledge preserving and transmission in the field of nuclear nonproliferation i.e. nuclear material physical protection, control and accounting (MPC&A), culture of MPC&A, studying of issues of nonproliferation, rehabilitation of harbor technical sites namely:

1. providing trainings and seminars on MPC&A and MPC&A culture;
2. issuing study guides on MPC&A and MPC&A culture;
3. interaction with other organizations and participation in round table discussions; and
4. enrolment of young specialists in Agency “Nonproliferation” activities and their active communication with experts; organization of additional seminars and round table discussions in the Agency for young specialists with participation of experts.

THE GEO-INFORMATION SYSTEM FOR THE ECOLOGICAL IMPACT ASSESSMENT OF NUCLEAR FACILITIES UNDER DECOMMISSIONING

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Data, information and knowledge relevant to the operation of nuclear facility are generated from the initial phases of design and sitting through the facility's life cycle including its decommissioning [1].

After the final shutdown of Unit 3 at the end of 2000 the Chernobyl NPP is under decommissioning. ChNPP is located in the area contaminated by long-lived radio nuclides (so called Exclusion Zone) where the ecosystem was significantly changed by this contamination. The final goal of the ChNPP decommissioning is the site condition described as a "brown spot" [2]; decommissioning involves measures for decontamination and dismantling of the contaminated structures; it is anticipated that the dismantling of building constructions and refinement of site will be considered taking into account the current radio-ecological state of the Chernobyl Exclusion Zone.

The knowledge about the ChNPP operation history, accidents (on 1982 and 1986) and measures undertaken to overcoming the accident consequences are very important to the choice of optimal decommissioning strategy with the minimal ecological impact and minimization of the personnel exposure during decommissioning. At the same time the national decommissioning experience for the nuclear installations of such scale and complexity is practically absent, therefore, the study and adaptation of international good practice in this field is very worthwhile.

The Kiev's research reactor WWR-M, which was commissioned 12.02.1960, is one of the first research reactors constructed and commissioned in the former Soviet Union. The operating license of the reactor was recently extended to 2015. Preparation for the further decommissioning of reactor was started in the framework of the Decommissioning Concept issued in 2001. The work on developing of this document is in progress now. This activity should be supplied by the careful evaluation of the dose loading on the staff and population with taking into account the different scenarios of normal operation and possible accidents. The site orographic features as well as the building wake effects may influence on the atmosphere dispersion and must be considered at the inhalation dose calculations. It should be noted that the research reactor WWR-M, which was constructed initially at the Kiev's outskirts, due to the permanent growth of mega polis becomes in the middle of a residential area with the high population density. So, it is very urgent to update the current state of safety assessment practice in line with best practice from IAEA guidance and information from other research reactors.

To solve above mentioned problems the development of the geo-information system for the ecological impact assessment of the proposed measures and to choices the optimal technical decisions was initiated in INR. This work is based on the experience of our previous investigations of contaminations around the ChNPP's site and radiological monitoring of another Ukrainian NPPs [3-4]. The conceptual scheme of proposed geo-information system is presented in fig.1. The basic information blocks include: standards, norms, regulations and guidance's of authority body, good practice review and event (incident/accident) analysis, the facility site characterization data and monitoring data, parameters of devices and installations, description of techniques, the FEP's list, conceptual model and computer codes for numerical computation, information concerning the selection and validity of parameter values, spatial distributed information, digital maps etc. For the systematization of the heterogeneity type information it is proposed the original taxonomy, tables of keyword, schemes of relations and straight through the joints. The modern software ArcGIS-9.1 (ArcView + ArcGIS 3D Analyst) and MS ACCESS (for single user version) are used for the management and data analysis. The system structure allows easy transformation to the multi-user system.

The current work stage is oriented on decision of following tasks: the filling of information blocks; development of statistical and geo-statistical tools for data analysis and the visualization of obtained results; development of the interface between the information blocks (base of parameter values and geo-data) and modelling tools.

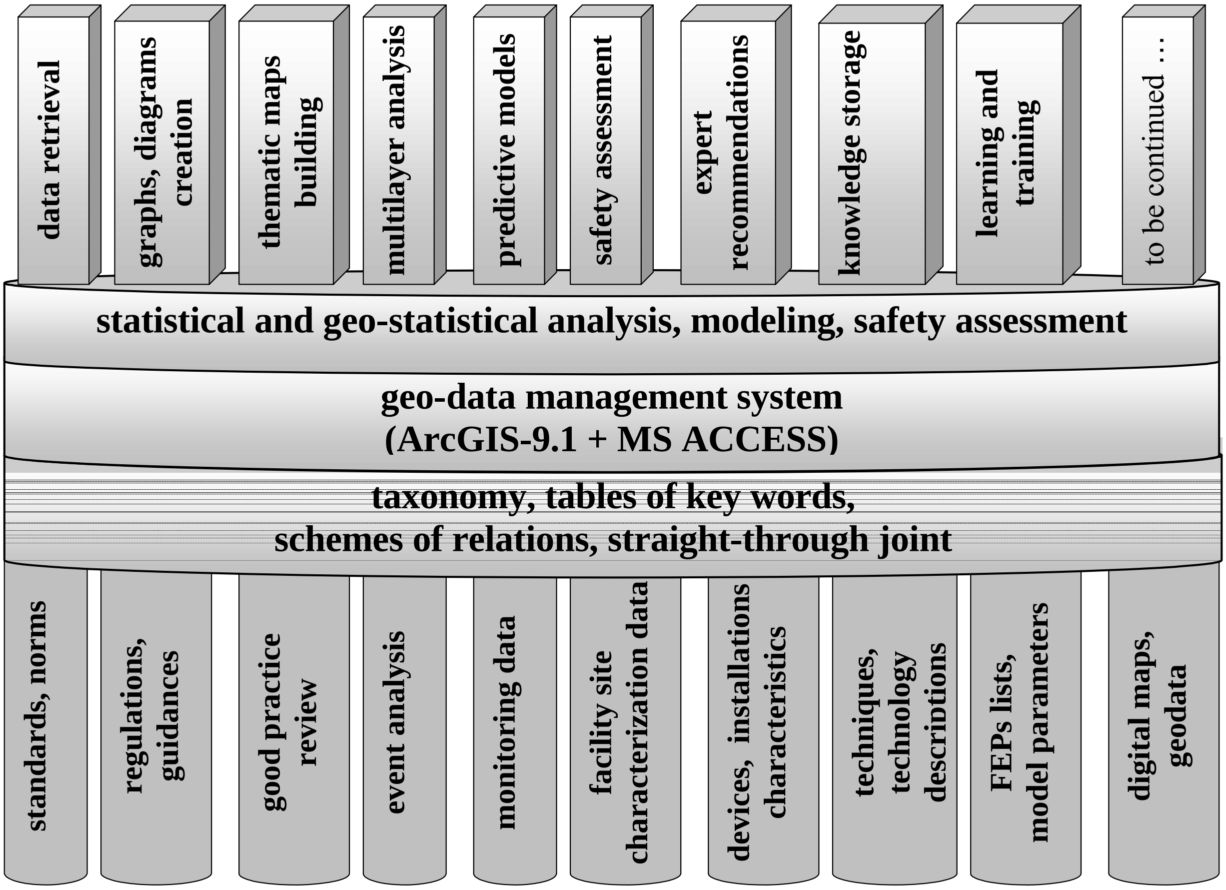

Fig.1 Conceptual scheme of geo-information system

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TRANSFERRING NUCLEAR KNOWLEDGE – AN INTERNATIONAL PARTNERSHIP

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The fast decrease of coal, oil and natural gas as energy resources is pushing the world towards the use of nuclear energy. The expectation of growth in the nuclear field seems to be a great challenge -specially- in developing countries which are in hard need of acquiring nuclear knowledge and nuclear technology as well. In this situation, various factors would have great influence on the implementation of nuclear projects -in particular- for electricity generation.

As a matter of fact, it is essential for each country to have its own strategy for national development. In practice, the implementation of such a strategy would need the collective efforts of specialized and efficient human resources for executing the tasks. This would need cooperation with, and/or technical aid of developed countries and international organizations.

There are various parameters that may contribute in the national development in a country, the most important of which are the development in science and technology. Then, the industrial development becomes essential for the nuclear industry. In order to achieve this, the information acquiring and knowledge transfer are fundamental tools.

The partnership between developed and developing countries would mean cooperation and aid directed to nuclear technology and knowledge transfer; and specialized technical training in the nuclear industry. Supplier countries might need to use high technology in implementing nuclear safeguards commitments, but with minimum side effects.

This paper investigates some factors that may have influence on transferring peaceful uses of nuclear knowledge and/or nuclear technology; such as establishing and sustaining the national nuclear workforce, building of public understanding and public acceptance of nuclear science and technology. Also, it discusses the importance of activating and strengthening the international regime of partnership for the welfare and prosperity of human kind; with specific consideration for the benefit and interest of developing countries.

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NUCLEAR SAFETY BASED ON NUCLEAR KNOWLEDGE – A ROMANIAN APPROACH

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The recognized "father" of the nuclear field, the scientist A. Einstein inherited us with a CONTRADICTION. On one hand he was the supporter of researches in the nuclear field, but on the other hand, when he saw the first devastating results of the atomic explosions he suddenly became a fervent opponent. In such conditions, the nuclear field made its first step in the conscience of humanity. Unfortunately it was a left first step. For this reason and also because of the nuclear incidents passed over the history of the field and due to yet unclear strategies regarding the final disposal of radioactive waste, a part of public opinion "embraced" the concept "NIMBY – Not In My Back Yard". At present and for the future we have to fight against this concept in order to transform it in PIMY – Please In My Yard". As a consequence, alongside numerous activities well-known by the specialists in the field, regulated and authorized by the regulatory body in the nuclear field, associated programmes for the CONTINOUS qualification and education of human resources are needed.

The Concept of Nuclear Security covers all the activities resulted from the nuclear fuel cycle. Taking into consideration the international experience in this field in our country's case, these activities were estimated for periods of approximately 70 years, as following:

- 10 years: the characterization and selection of the site, the design, construction and the commission of a nuclear power plant;
- 40 years: the operation, maintenance and modernization of a nuclear power plant;
- 20 years: the preservation for the decommissioning and the decommissioning of the nuclear power plant.

In all these stages until present Romania based a lot on the indigene component regarding the activities of research & development, design, construction – assembling, exploitation and maintenance (both for NPP Unit 1 and Unit 2, where this component was approximately of 50%).

In such conditions, it was needed the elaboration of a National Nuclear Programme (PNN), strategically document approved by the Governmental Decision no. 1259/2002 which contains the fundamental objectives and the derivates objectives and also the associated strategies for accomplishing these objectives. The strategic document was published in the Romanian Official Journal in order to be near at hand for the public and increase the debate and acceptance of the nuclear field. The National Nuclear Programme contains an associated plan of actions with responsibilities and terms of achievement for the activities which fall into the responsibility of public central administration institutions representing "the owner", into the responsibility of the national companies representing "the utility" and into the responsibility of nuclear units themselves representing "the operator".

All these above mentioned activities need a source of labour, human resources, qualified and specialised both on the research & development, design and exploitation component and the execution equipment, construction – assembling, exploitation and maintenance component.

The qualification and the specialization of these types of human resources enforced the identification and the definition of associated programmes for the qualification of the staff starting from high schools and universities. Related to this education programme, the same strategic document nominates in an explicit manner 4 Romanian universities which have to take into consideration educational programmes in the nuclear field:

- Polytechnic University – Bucharest;
- Piteşti University;
- Faculty of Phisics within University of Bucharest;
- Ovidiu University – Constanța.

Within the education framework of these universities are taking place lectures, seminars, workshops and also master and doctorate courses. These types of qualifications were selected based on 3 primordial criteria:

- The competence of the teaching staff;
- The geographical location nearside nuclear units/important Romanian research centers;
- The possibility of training stages within these units/centers.

In this manner "the source" of human resources working now and in the future in the nuclear field is easy accessible and the continuity is assured. In this context it must be mentioned that were developed universitary educational programmes for young people wishing to work in the nuclear field and also post graduating programmes addressed to improve knowledge in the nuclear field for the personnel which is already working in the nuclear field in the design, execution equipments, construction – assembling, exploitation and maintenance activities.

We have to take into consideration the fact that the migration of qualified human resources and the average level of age of the personnel involved in the nuclear field are considerably high. These 2 factors are representing aspects with which are confronted all the actors in the nuclear field, at an international level, including Romania. For these reasons, the Romanian PNN defines the strategy through which the education process must take into account these problems starting early, from the high school level.

Concluding, attracting and developing human resources at a national level , needed in al stages of promotion, design, construction and exploitation of the investments in the nuclear field remains a challenge for the nuclear community in general but also for the decision-making factors at a governmental level, the industry and especially for the academic level. This challenge involves the existence of 4 strategic directions:

- A legislative package needed for the promotion and the development of nuclear field;
- A knowledge data base in the nuclear field;
- Qualified human resources, capable to work within different types of activities in the nuclear field; and
- The transfer of knowledge to future generations.

DIGITAL PRESERVATION TECHNIQUES TO FACILITATE KNOWLEDGE MANAGEMENT IN THE NUCLEAR SECTOR

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The advances of computer technology offer many new opportunities but also new challenges. One of the most crucial challenges is tackling the problem of digital preservation: ensuring that the digital information we create and store today will continue to be accessible for as long as we may need it. Industry commentators have raised the prospect of a 'digital dark age' stretching from the late 20th to the early 21st century, as huge amounts of digital information are at risk of being lost. The problem is becoming well known:

- Storage media such as magnetic tapes and disks and CD-ROMs have a finite lifetime.
- Storage media formats change rapidly (consider how few people still have a 5.25 inch floppy disk drive).
- Most challenging of all, the file formats in which information is stored rapidly become obsolete as new software packages appear and older applications become unsupported and unavailable.

In other words, if the lifetime of digital records exceeds that of any part of the software/hardware stack used to create them then the owners of those records face a potential digital preservation problem. Tessella has been working with government and private sector organizations to develop solutions to the problems of digital preservation. This presentation outlines the problems and potential solutions based on Tessella's experience working with the UK National Archives, the Dutch Nationaal Archief, and most recently the US National Archives and Records Administration (NARA) on systems and strategies to ensure that 'born-digital' records are stored and managed safely and securely, and continue to be accessible into the distant future. This is essential both to maintain the accountability of governments, for our cultural heritage and to meet regulatory compliance in areas as diverse as the Nuclear, Aerospace and Pharmaceutical sectors. Tessella are actively researching innovative strategies to ensure that digital information can survive reliably as hardware and software technologies come and go. The paper uses examples of platform migration strategies used to ensure reliable access to nuclear research data as well as data management strategies for the long term acquisition, management and access to geo-sphere data used in the selection and design of waste repositories.

KNOWLEDGE MANAGEMENT FOR IMPROVED OF EMERGENCY PREPAREDNESS AND RESPONSE AT NUCLEAR FACILITIES

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Sustaining of knowledge management poses inseparable part of safety maintenance at a nuclear facilities and provision of competence of regulatory authority [1, 2]. In the report key issues are considered to achieve the proper level of staff competence of operating organizations and the regulatory authority in domains of nuclear safety at Russian Nuclear Research Facilities (NRF)[1] on the basis of international fundamental principles of safety [3].

The principle of prime responsibility for safety was established at legislative level in Russia [4, 5]. Federal environmental, industrial and nuclear supervision service of Russia (Rostechnadzor) carries out major functions of the regulatory body of nuclear and radiation safety including development of regulations and guides, authorization, review and assessment of safety; inspections and enforcement measures. Moreover, Rostechnadzor’s competence includes arrangement to ensure functions of the state subsystem to oversee the emergency situation at objects of the use of atomic energy [6,7].

In current practice operating organization fulfils knowledge management of personal including training, retraining, and provision of qualification skill. Rostechnadzor issues permits conferring the right to carry out activities in the sphere of the use of atomic energy [8]. Rostechnadzor's employees’ qualification and skills levels are being tested on the basis of Federal law «On Public Service in Russian Federation» [9]. The regulatory body develops comprehensive system for staff skills in all domains of regulation of nuclear and radiation safety. The scope of necessary knowledge of state employees includes issues of legislation, regulation, safety of nuclear facilities, radiation protection and monitoring, information technologies and communication, public relations, psychology and other areas of knowledge. Problem of emergency preparedness and emergency response are fundamental importance for facilities in operation and includes all listed above specific knowledge.

With purpose to make deeper knowledge of severe radiation problems the objective was posed to revise calculations, which have been done before for calculation of radiological consequences in result of potential severe accidents at NRF on the basis of modern methods and certificated computer codes [10].

Advanced information technology provides proper quality of documents and effective access to necessary references has to be implemented to support the emergency procedures [11, 12].

At present in the framework of IAEA technical co-operation the national project “Strengthening of emergency preparedness and response at nuclear research facilities” (RUS/9/005) is being realized. Plan of works includes arrangement for creation of information system to support emergency preparedness and emergency response at NRF, creation of mobile inspector’s office, development of effective knowledge management strategies and

[1] NRF - will be interpreted buildings and sites with civil research nuclear reactors, critical and sub critical nuclear assembles, which have been designed for utilization of neutrons and ionizing radiation for research purposes.

programmes, improvement of incident reporting system of NRF, and interdepartmental interaction.

Development of national project will provide enhancement of safety culture, effectiveness of knowledge management at nuclear facilities and regulatory body of Russia. The experience related to the national project implementation may be used by IAEA for improvement of knowledge exchange and arrangement of regional project on strengthening of emergency preparedness and response at nuclear installations.

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THE MANAGEMENT OF KNOWLEDGE, ACQUIRED IN THE MANAGEMENT OF RADIOACTIVE WASTE – THE RESULT OF PREVIOUS ACTIVITIES

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The main purpose of radwaste management is reliable isolation of waste that ensures radiation safety of the human beings and of the environment for the whole period of radwaste being of potential hazard.

All radwaste on the territory of the Russian Federation could be subdivided into:

- RW which is being generated nowadays as a result of operation of nuclear facilities, radiation sources and storage facilities;
- RW accumulated as the result of previous activities in the process of implementation of defense programmes on development of nuclear weapons at nuclear fuel cycle facilities and other types of activities. This RW is kept in water-basins, tailing ponds and other RW storage facilities.

In the process of implementation of defense programmes a lot of radioactive waste was accumulated in the mentioned facilities and a lot of storage facilities are not equipped by the system of barriers on the path of expansion of ionizing radiation and radioactive substances, which is required according to up-to-date safety conception, or the available system of barriers is not ultimate.

Nowadays, the significant experience of management is accumulated in the Russian Federation and it has got a lot of requirements which were established by the system of normative regulation.

The regulatory system based on the experience accumulated in the process of management of radioactive waste has established a number of safety regulatory requirements in the management of RW, accumulated in surface water-basins and tailing ponds, including the following:

1. there shall be provided technical facilities and administrative measures, aimed at the prevention of:
    - exposure of the workers (personnel) and population above the limits, established by radiation safety standards;
    - contamination of the environment, including contamination of surface water-basins and underground waters with radio nuclides;
    - wind-induced carry-over of radioactive aerosols, dust generation and radionuclide carry-over with dust.
    - radiation monitoring shall be provided, including radionuclide and chemical composition of the water phase and bottom sediment, radionuclide and chemical composition of environmental contamination (atmosphere, ground).

2. there shall be provided monitoring of the state of the surface LRW water basins and tailing ponds, including monitoring of:

- incoming waste (nomenclature, amount, radionuclide and chemical composition);
- state of the barriers (amount of water filtration-loss, radionuclide migration to the environment, radionuclide and chemical composition of the underground water).

3. the operator shall develop and implement technical and administrative measures, aimed at:

- limitation of radionuclide ingress into the surface LRW water-basins and tailing ponds;
- prevention of non-permissible discharge (leakage) form the surface LRW water basins and tailing ponds to the surface and underground water bodies and to the ground surface;
- decommissioning of the surface LRW water basins and tailing ponds.

4. for each surface LRW water basin and tailing pit the following will be defined and justified:

- RW storage period;
- amount (mass, volume) of stored RW;
- radionuclide composition, specific and total activity of stored RW;
- standards of RW ingress;
- amount of water filtration-loss;
- maximum values of radionuclide migration into the environment.

5. to define the necessity of implementation of technical solutions and administrative measures, aimed at improvement of the safety level of RW storage facilities under operation, there shall be performed an analysis of their current safety level and prediction calculation for safety assessment of the RW disposal system. By results of the analysis and prediction calculation all reasonable practically realizable measures shall be implemented.

The normative regulation for radioactive waste accumulated in the process of previous activities demands the development of a specific approach.

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JAPAN NUCLEAR TECHNOLOGY INSTITUTE ACTIVITIES

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1. Introduction of JANTI

Japan Nuclear Technology Institute (JANTI) was established in April, 2005 by consent of Japanese nuclear industries such as electric utilities, manufacturers, subcontractors etc., and its members consist of 114 companies. JANTI has two major purposes. One is to support industrial initiatives for safety operation on the model of INPO. The other is to improve regulatory practices to agree with the state of the art nuclear technology based on operation data.

JANTI promotes three core stones such as Operating Experience Analysis, Nuclear Safety Network and Codes and Standards. Our activities are based on knowledge management by gathering, evaluating the operation experiences from domestic and overseas nuclear power plants, promoting safety culture and industrial standards for safety operation by reflecting on lessons learned from operation experiences.

2. The out line of activities

JANTI took over and enhanced information-gathering / delivery / utilization operations of the Nuclear Information Center, which was established in 1983 under the Central Research Institute of Electric Power Industry to incorporate lessons learned from the TMI (Three Mile Island) nuclear accident. The following items are implemented:

(1) Sharing operational experiences from nuclear energy facilities (nuclear power plants, fuel cycle facilities of Japan Nuclear Fuel Limited) to issue recommendations based on event analysis.

(2) Conducting trend analysis of operation information to provide feedback on plant operation and maintenance work by exploring a database to counter issues associated with facility aging.

(3) Utilizing operation information and equipment reliability data, data for probabilistic safety assessment and drawing up the guidelines for reliability centered maintenance / condition-based maintenance.

2.2 Promoting safety culture

JANTI took over and evolved the rules of Nuclear Safety Net, which was established to incorporate lessons learned from the JCO nuclear accident in 1999. Efforts were made to optimize NS Net operations based on its past activities, while maintaining the positive aspects of the Peer Review mechanism. The following items are implemented:

(1) Performing Peer Review with the help of INPO and establishing JANTI Peer Review.

(2) Promoting safety culture

2.3 Developing voluntary consensus standards

As Japanese laws begin to incorporate performance oriented standards, there is a need for developing voluntary consensus standards.

(1) Grasping industry needs and drawing up a roadmap for them.

(2) Supporting the development of voluntary consensus standards

3. Summary

The capacity of the nuclear industry has been amassed to establish JANTI as an institute for developing the industry's technological foundation, promoting industrial initiatives for safety operation and contributing to the revitalization of the nuclear industry itself. Its basic policies are to use scientific, rational data and knowledge to contribute to enhancing industrial initiatives for safety operation. Especially, as the recent topic, Japanese utility revealed the critical event by inadvertent rod withdrawal which happened in 1999. It enhanced JANTI to improve our activities furthermore. Its outline and the countermeasures will be explained at the meeting.

ROLE OF TECHNICAL SUPPORT ORGANIZATIONS IN DEVELOPMENT AND MAINTAINING KNOWLEDGE MANAGEMENT SYSTEMS FOR RUSSIAN REGULATORY BODY

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The task of maintaining knowledge in the field of atomic energy is one of the most important challenges of today. The development of science and technology has reached a level when passing the accumulated knowledge becomes labor- and resource-consuming, demanding for significant time expenses, which is conditioned, as we know from the theory of knowledge management, by an inevitable process of transformation of knowledge when passing it from one individual to another. Under such circumstances, proper attention should be given to the problem of knowledge maintenance and transfer.

The responsibility of the state nuclear safety regulatory authority that oversees how properly the facilities ensure safety requires highly competent experts of the regulatory authority and constant and complete use of the experience in regulatory activities (including theoretical knowledge and practice), which is possible only if there is a well thought-out and effective knowledge management system.

Considering the limited resources of the regulatory authority itself, one of possible ways of accomplishing the task is involvement of a technical support organization (TSO) in development and maintenance of the knowledge management system. Such an approach is a practice in a number of countries, which was repeatedly pointed out by the speakers at the International Conference on the Challenges Faced by Technical and Scientific Support Organizations in Enhancing Nuclear Safety held in April 2007 in France.

The Russian nuclear and radiation safety regulatory authority is not an exception. Its technical support organization, FSUE VO "Safety", is directly involved in implementation of the regulator's task of continuing enhancement of the level of competence of its experts by means of development of a knowledge management system.

It should be noted that the way our organization approaches the knowledge management system is an obligatory combination of two subsystems – educational and information process ones.

The educational subsystem implies ongoing work on enhancing the regulatory personnel's qualification drawing new knowledge and expertise, studying documented and archived expert solutions, continuously improving the educational programs and training courses, developing methodologies of accumulation of practical skills in accordance with the required competence. This work is performed by FSUE VO "Safety" jointly with dedicated training centers.

The information process subsystem is a computer system of knowledge storing, which consists of data bases, a search system and expert system to support decision making.

Any expert's query is processed in this system using the material from the data bases populated by the experience of other experts. If a situation described in a query has taken place and filed in the date base, the expert obtains a pre-determined way to accomplish a task. Otherwise, the query comes to the analytical center where a team of experienced experts together with the inquirer looks for a solution to a given problem with subsequent filing of the solution in the data base.

At present, the educational subsystem has been implemented to a phase when it can be practically used, whereas the information process system is in making through integration of data bases of various aspects of the regulator's activities and design of the search and expert systems.

The information process system under development is originally oriented toward close integration with partner organizations in the field of maintenance and propagation of scientific and technical knowledge in the framework of the so called Global Knowledge Network.

KNOWLEDGE MANAGEMENT APPROACH TO EMERGENCY PROCEDURES IN NUCLEAR FACILITIES

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Nuclear Knowledge Management is thought to be a discipline mainly concerned with the preservation of knowledge in specific areas of nuclear science and technology [1]. This paper will be discussing the possibility of applying knowledge management approaches bringing benefits of efficiency and responsiveness to activities performed on daily basis by nuclear workers at nuclear facilities. This includes activities performed by national and IAEA nuclear inspectors.

A process-oriented Knowledge Management System (KMS) based on KM-Services, namely the PROMOTE approach is described. This is a top-down approach that allows defining business processes and the consisting knowledge activities. On the basis of the so called Knowledge Management Processes (KMPs), which aim at capturing the interaction between the knowledge workers in a process-oriented manner, knowledge activities like searching, categorizing or storing information are supported by so called Knowledge Management Services (KMS) [2]. This constitutes of the technological layer which serves as an enabler in making the most of available technology wherever and however accessible. The aim is to study the potential of implementing an Knowledge Management System based on business processes that commonly execute at a nuclear facility. The proposed KMS architecture and various models based on the PROMOTE approach are discussed.

One of the common processes executed by safeguards inspectors in nuclear facilities is the physical inventory verification and the interim inventory verification. These consist of activities that are based on well defined procedures and are executed by inspectors regularly. A model capturing the interaction between inspectors and facility operators will be used to demonstrate the immediate benefits of a knowledge management approach. By identifying the knowledge intensive tasks, the objective is to offer nuclear inspectors with knowledge in a explicit form when found in unfamiliar and emergency situations. Such situations may be caused by events at the facility or unavailability of surveillance and measurement systems. The aim is to provide the inspectors with knowledge that will allow them to react quickly and appropriately. Explicit form of knowledge includes, but is not confined to, topic maps, variety of information products and other resources that lead to understanding new situations. Furthermore, knowledge activities required to deal with such situations can be supported by KM services making the most of that available technology. Since KMS is seen as a socio-technological system [3] the benefits of the PROMOTE approach is that it offers integration not only at the technological level but also at the application level.

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MAINTENANCE OF NUCLEAR COMPETENCE UNDER THE PERSPECTIVE OF THE NUCLEAR PHASE-OUT IN GERMANY

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The situation of nuclear energy in Germany is characterized by the phase-out policy pursued by the current government, which means that the last German nuclear power plant will run until about 2022. The actions taken to nevertheless maintain the nuclear competence needed in Germany are shown. Then the role of the “Alliance for Competence in Nuclear Technology” in bundling the current publicly funded research and teaching activities is explained. The strategic goals of the Alliance include support of qualified young scientists, enhanced cooperation with universities and support of international initiatives (e.g. ENEN, WNU etc.). To stabilize fundamental education in nuclear technology, the Alliance has established a regional “adoption concept” in cooperation with German utilities, manufacturers, and nuclear technology training and research institutions.

LINKING KNOWLEDGE MANAGEMENT PRACTICES TO NUCLEAR POWER PLANT ORGANIZATIONAL PERFORMANCE

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This paper summarizes research underway at AECL that is being conducted under a research agreement with the IAEA as part of the IAEA's larger Coordinated Research Program on Nuclear Knowledge Preservation and Management (KM). The paper describes the research program objectives, approach, and preliminary findings to date.

Knowledge management practices have long been cited as an important factor in achieving overall organizational effectiveness. Many authors in the academic literature have studied the links between KM best practices and firm performance. Various nuclear power plants (NPPs) around the globe have begun to recognize the strategic importance of KM initiatives in achieving sustained overall operational performance. The awareness of the need to manage knowledge and ensure its effectiveness in the NPP organizational context varies from plant to plant. Several NPPs have been early adopters of KM thinking and practice, and have been proactive in implementing KM initiatives. However, at other NPPs the concepts and benefits of KM are only beginning to be understood and applied. The various approaches taken to KM and the relative benefits obtained from KM initiatives is expected to vary from station to station.

Although a significant body of academic research literature exists on the subject of KM and its impact on performance in organizations, very few empirical studies have been reported in the literature that directly explore the relationship between the extent or maturity of KM practices and overall organizational performance. In general, the issue has not been extensively researched and is not well understood. Further, little or no empirical research has been done on this topic in the specific context of NPP operations. Several factors are thought to influence the effectiveness of KM initiatives in improving NPP performance. For example, organizational culture, including the safety culture and leadership support for KM are thought to be important. Other issues, such as the extent to which KM practices are aligned with and support operational best practices are thought to be significant. For example, life-cycle equipment maintenance and configuration management of the plant design basis information are both areas where KM initiatives may have a positive impact. Finally, the extent of adoption and maturity of KM practices in a NPP may be a key factor.

The objective of the research is to obtain a deeper understanding of KM in the NPP context and in specific to investigate and establish the relationships between KM practices and its overall impact on the utility's organizational performance. By gaining insights into what factors affect the successful implementation of KM in NPPs, into what specific knowledge management strategies and tactics have proven effective in NPPs and what benefits have been achieved, much-needed guidance can be provided to NPPs to help maximize the benefit from their KM initiatives and achieve and maintain improvements in operations.

Effective knowledge management enhances an organization's capability to capture and fully utilize its existing knowledge base and it is widely recognized, both in the management literature and in industry practice, that KM is an important driver of performance and essential to maintain competitive advantage. It is argued that the role of KM is particularly important in technology-intensive industries such as the nuclear industry. Further, it is argued that knowledge management practices, if effectively applied to nuclear power plants, enable operational and safety performance improvements, including reductions in operational and personnel safety risk, and opportunities for plant design improvements.

However, introducing and maintaining effective knowledge management processes (i.e. a KM system) in a nuclear plant is difficult and challenging. Many utilities are making progress towards the implementation of different knowledge management processes and support systems, but in general, progress lags many other industries and higher than expected implementation effort is being experienced. Further, nuclear utilities may not always be able to determine the effectiveness of KM processes, and in some cases may not be able to identify key areas in need of improvement. As a result, knowledge management initiatives may not always provide all of the expected benefits. This underscores the need for improved KM strategy, implementation, measurement, and ongoing re-alignment.

It is argued that KM in the NPP context has additional challenges. Some of the issues faced by the nuclear industry include: a complex technology base and infrastructure (i.e. both from a design basis perspective and from and operations and management perspective); lengthy technology and plant life-cycles; highly capital-intensive plant assets (and thus the need for risk-informed asset management decision processes); a reliance on multi-disciplinary technologies and expertise; competing operational objectives of safety, economics, and production; potentially high hazards that must be systematically managed to demonstrably low tolerable risks; and finally, the ongoing need for coordination of complex physical and human systems. On top of all this, stringent requirements for safety, environmental qualification, nuclear quality assurance, and equipment/design configuration management must be met, all in the context of a regulated industry environment.

Whether formally recognized in a given nuclear utility or not, it is argued that successful and superior life-cycle operation of any NPP is dependent on effective KM processes. Thus a key hypothesis of the research is that the maturity and alignment of KM processes in supporting NPP operational best practices are vital and necessary ingredients to achieving superior overall long-term utility performance. KM processes are believed to enhance and help maintain a pro-active organizational culture that focuses on problem avoidance. By empirical study, this research will attempt to establish that NPP organizations with properly focused and mature KM programs and practices that facilitate effective learning processes at all levels in their organization enable better utilization of knowledge, and when this is combined with strong KM leadership and a culture that promotes safety and quality values, superior pro-active decision making and higher work-process effectiveness and efficiency is achieved.

As part of this research, a review of current literature on KM practices and its affect on organizational performance is being conducted. A formal survey instrument based on the review findings is being administered to operating NPPs in cooperation with the IAEA and will benchmark KM practices and performance indicators. This paper will present the findings of the research to date.

TO EFFECTIVELY ADAPT AND RENEW WORKFORCE COMPETENCES

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Most of French operating nuclear plants were constructed within a small time window. Few new plants have come on line within the last decade. As a result, most operating plants today have an ageing workforce that is going to retire in large numbers. In the next ten years, 40% of EDF nuclear workforce is going to retire, in average 600 people per year.

At the same time, potential restructurings are opportunities to provide internal personnel for Nuclear Power Plants.

The first generation of nuclear industry workers was hired during nuclear plant starting and testing. That was an opportunity to for training in the field without nuclear hazard. In addition, the NPP requirements increased dramatically through the last twenty years.

This situation led to start a project to effectively adapt and renew workforce competences in the 19 EDF NPP in France. This Paper describes three steps to successfully ensure this transition to the new generation of nuclear industry workers.

Acting in the field from their initial training, recruits are earlier ready to perform:

- A Nuclear Job Academy in each French region based on Team Building and Sister Plants association, new training techniques and field training regarding behaviour and craft. All the new comers in Nuclear Power Station are led by an experienced technical mentor and trained by managers and experienced staff.
- Flow loop maintenance simulator in each plant.On line training and test for periodic training.Step by Step qualification process.

Internal workforce moving and rotation become a consistent, safe and successful opportunity to renew competences:

EDF Group promotes the mobility of human resources by improving skills management (training programs, encouraging profession mobility, and reorientation towards priority jobs).

To ensure that each nuclear new comer from internal workforce meets the nuclear requirements (as hired people), we build strong process witch guaranty internal people recruitment with potential to work in nuclear plants, develop nuclear skills, behaviors, and capacity for the job.

For each of the most important job areas (Operation, Maintenance, Chemistry, Electricity, Health Physic), we built:

- A requirement regarding both profile (diploma, job experience) and training needed
- A promotional campaign based on a technical form describing the job, profile requirement, training needed, skills ability test),

- A process enrolment based on a regional 'job café meeting', cross interviews, and job try out,
- Enhancement Training Program to achieve the enrolment level.

Management gets Total Commitment to competence improvement leadership:

A Knowledge and Competence Management Training Program is developed from observation in the field to competence assessment and Personal competence progress interview.Management is also involved as workforce trainers.

KNOWLEDGE MANAGEMENT AND THE NUCLEAR RENAISSANCE

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As the nuclear industry prepares itself for a new and potentially large growth spurt in the near future, people are suddenly becoming acutely aware of the demands such growth will place on the existing infrastructure. We will need more large-component manufacturing capacity. We will need more uranium. But most of all, we will need more people—skilled craftspeople, highly-trained operators, nuclear-trained engineers, and experienced regulators. This need is developing just as the cohort that designed, built and operated the existing facilities is reaching retirement age. Thus, the usual internal corporate means of knowledge transfer—informal mentoring and on-the-job training, are being strained. In the short term, there is concern that organizations are trying to meet their staffing needs by "raiding" each other for experienced personnel. If even a fraction of the current predicted growth in nuclear capacity is realized, this will not be a viable solution.

A number of initiatives are beginning to emerge to deal with the need to transfer skills and knowledge, both within organizations and across them. Most of these can be classified broadly as "knowledge management" initiatives. These include:

- Improvements in the way internal records are documented are maintained, indexed and made available.
- Structured programs to capture and transmit undocumented ("tacit") knowledge.
- Programs to share knowledge and lessons learned, both across the industry and across nations.
- Internal and external training programs.

This paper will review some of the major directions, initiatives, possibilities and limitations in these areas.

RETENTION OF KNOWLEDGE AND EXPERIENCE FROM EXPERTS IN NEAR-TERM OPERATING PLANTS

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Tianwan Nuclear Power Station (TNPS) will be put into commercial operation in May, 2007. Right-sizing is on the way to adapt the organization to the new stage of TNPS. TNPS is facing challenges of dilution of expertise by the rightsizing. This condition is aggravated by the incipient training system and a very competitive fighting for attracting technical experts in nuclear area, because the very ambitious projects of nuclear plants which are thriving in China. This can lead to the compromise of the capability to safely and economically operate TNPS.

Indubitably, a personnel training plays a very crucial role in knowledge management, especially for countries as China which are weak in professional education system. Key knowledge and skills for safely and reliably operating nuclear power plants can be effectively identified by personnel training system developed in a systematic way and properly implemented. And only by sound and sufficient training can adequate number of replacements be produced.

Well-developed IT platform can help the information management in such an era of information and internet. Information should be collected in a systematic way instead of stacking information on an ad hoc basis. But the project database must be established in an well-organized way, and the information should be aroused from sleeping, so that usable data will not be lost and are readily accessible on intranet and available to users. Or else the engineers take great pain to search for data like looking for a needle in a haystack, while useful data are gathering dust somewhere deep in the databank something.

Compared to the well-developed industrial countries, there is quite a room in fundamental aspects which are cardinal requisites for effective knowledge management. These factors Contributing to Knowledge Management in Near-Term Operating Plants include not simply training and information management but also almost all other technical and management related to the safety and quality of nuclear power plants.

For example, documentation/procedure system can have a big effect on the knowledge management. In order to keep complete information of the procedures and their change, not only should the change be documented, but also the cause and effect of the change should be formally documented.

Human resource is essential support for successful knowledge management. It is well know in the industry that the implementation of SAT is very resource-consuming labour, especially for human resource. And well-kept information manage system need not just experts in archive and computer technology, but also expertise in operation, maintenance, etc. to fulfill the function in data collecting, analyzing, keeping, organizing, and utilizing. Furthermore, there should be additional personnel deployed in operating, maintenance departments to support the function of knowledge management. And to make the matter worse, strain of human resource on knowledge management is a chick and egg situation.

Above all, managers' recognition of the significance and impact of knowledge management is the decisive factor and of paramount importance.

Therefore, to spur the successful application of knowledge management, it is not enough to call on the training and information management experts to focus on knowledge management by TECDOC or conference. More intense measure should be taken to attract the attention of higher management, as high as possible, by items in safety standards, performance objectives and criteria, or OSART Guidelines. And the transfer of good-practice and experience should be extensive by many and various ways, e.g. workshop, document and experts exchange, so as to cover all important elements in knowledge management and narrow the gap between newly operating organizations and well-developed organizations.

KNOWLEDGE MANAGEMENT AS AN ELEMENT IN REALIZING NUCLEAR TECHNOLOGY

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A company is not defined by its competences but it lives in realizing these competences in products. The technical knowledge within the field, i.e. here in nuclear technology, is taken as granted at a first glance. For analyzing the role of knowledge management (KM) in the application this knowledge for our products, one can follow two different dimensions, thereby elucidating the needs and development requirements for KM methods:

When first considering the *'operational' dimension*, one can start from the scope of the manufacturer's knowledge which covers the construction of plants, then accompanying its life cycle, and pursues the development of the technology for the future. A board spectrum of KM activities has been established yet for these different phases, comprising tools with close product orientation or KM elements applied in 'support processes'.

In cases of close KM integration in the business process, diversity over the different sectors of the company has emerged: 'locally' optimized solutions are favoured due to specific requirements of the technical field, to continuity or to ease of daily application. On the other hand, 'global' KM tools are often preferred for integration in 'global' support processes (as human resource (HR) management).

This can be illustrated by some examples deployed yet, and their benefit:

- ❖ Feedback procedures for new plant projects:
  - capturing the experience during construction (e.g. by standardised reports), thereby strengthening quality criteria for the project and integrating evaluation into the project management (PM) process of the current project,
  - thus reducing erection time – and related capital cost – for future plants.
- ❖ Follow up event information on nuclear plants globally
  - by collecting and assessing events systematically for proactive

    technical action and as input for quality management (QM),
  - thus identifying market needs in advance also.
- ❖ IT based KM tool used in nuclear maintenance service:
  - supporting PM as a planning tool, making available technical data, checklists and 'lessons learned' by a systematic data base solution,
  - thus resulting in plant service optimized in respect to technical reliability and duration.
- ❖ Expert networks:
  - leading the technological progress in our own core competences, while keeping high quality by 'distributed' evaluation of the new developments,
  - thus optimizing R&D budget allocation and follow-up development success.

- ❖ Developing human resources (HR):
  - defining consistent knowledge profiles for the employees for future projects
  - thus ensuring a well adjusted workforce – a main cost factor within the company.
- ❖ Mentoring:
  - for transfer of project skills and experience, fostering new ways and solutions,
  - thus maintaining knowledge and facilitating the start-up phase for young employees.
- ❖ External co-operations in R&D:
  - an approach for complementing own knowledge by identifying alternative approaches,
  - thus resulting in mutual benefit for the external institution and the company, keeping it on the edge of progress in a competitive environment.

For the second step, the analysis of KM in the other – *'contextual' – dimension*, it becomes apparent from examples that knowledge is applied usually in the context of project management and quality management. Both PM and QM are well established and organized under standards and guidelines, using 'best practices' and tools often applicable in other industries as well – a goal for KM as well.

Obviously successful projects require close, complementary interaction of the three management aspects, and none of them can replace one of the others. KM is not a stand-alone basis for the product; in contrary, PM and QM are focused more tightly to the business process, relying on KM support in the 'back office' – and in many cases they are 'driving forces' for KM deployment. In this way, most of the aspects discussed usually for KM – as identification of knowledge gaps, acquisition of knowledge, its development, sharing, use, preservation and evaluation – derive the criteria from the business process and therefore they are in part tasks in PM or QM also.

In *summary*, key aspects for deployment of KM in the different 'operational' phases can be derived considering both dimensions:

- ❖ for construction:
  - intensify the integration of KM with PM and QM, as often they link KM more closely to the realization processes,
  - organize 'on-line' evaluation of project feedback information,
  - allow 'localized' tools and procedures, making easier adjustment and acceptance,
  - use the project environment for mentoring and employees' competence profile definition, fulfilling both training and QM needs;
- ❖ for accompanying the plant's life cycle in service and retrofitting:
  - structure the collection of information proactively and ensure the evaluation,

  - develop KM based decision support for regular service (e.g. anticipating the risks),
  - integrate KM, PM and QM in the related maintenance projects also;
- for technical development, complementing the company's strategic orientations:
  - derive and select R&D objectives by the KM based results from erection and life cycle,
  - link internal and global technology progress by expert networks,
  - extend the innovative scope by conscious external R&D co-operations.
- Challenges remaining for further KM development are found at the interfaces mainly:
  - the different 'localized approaches' should be integrated into a 'modular' KM landscape,
  - well adjusted interaction of these tools and procedures among the phases should be intensified,
  - the simultaneous use of internal sources and the KM tools in the public domain has to be fostered.

THE NEA KNOWLEDGE MANAGEMENT PROJECT

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Over the last 50 years significant knowledge has been accumulated in nuclear technology. This knowledge can be categorized as explicit and tacit. Explicit knowledge includes documented information while tacit knowledge refers to the knowledge acquired by experts over a long time and is more difficult to capture. The goals of knowledge management program are to retain explicit and tacit knowledge, encourage sharing of this knowledge, create and facilitate communities of practice and insure that knowledge is easy to find and readily accessible.

The NEA committees have had extensive involvement in the accumulation of technical information in the scientific research, engineering studies, state of the art reports and many other endeavours that contribute to the technical basis for many safety and technology decisions. Many of the NEA reports (SOARs, Survey reports on safety topics, etc.) are in fact examples of knowledge management activities. The NEA committees' working groups are an excellent example of communities of practice.

Over the past decade or more there has been an erosion of scientific resources due to reductions in budgets, aging and retirement of many outstanding scientists, engineers and managers, loss of experimental facilities and reductions in educational programs in nuclear engineering. The NEA has fully recognized this concern and has published many reports on this topic (e.g. Nuclear Education and Training: Cause for Concern?, Future Nuclear Regulatory Challenges). With the industry push to reduce conservatisms in decisions and increased interest in building new nuclear power plants it becomes imperative that additional mechanisms be developed to make available both the tacit and the explicit knowledge to the new generation of engineers and scientists for safety and technology decisions. The NEA strategic plan (also the individual committees' strategic plans) recognizes the importance of this issue and recommends:

- Promote the transfer and management of knowledge
- Promote the collection and safeguarding of important and well documented results from experimental studies

A small magnitude of effort pilot project, focused on documented (codifiable and explicit) activities of three committees, was undertaken. Boron Dilution was selected as the pilot topic based on previously agreed to prioritization criteria by the three committees. This presentation provides the lessons learned regarding the ease or the difficulty of accessibility of the documented information on the pilot topic as well as the clarity of purpose and the relevance of the results as documented. This project also examined the degree of integration and linking of the documented activities of the three committees on boron dilution. These lessons will be considered by the NEA to determine what NEA processes could be improved to ease access and transfer of relevant NEA generated scientific information.

MANAGING NUCLEAR KNOWLEDGE - OBJECTIVES AND OBLIGATIONS

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Nuclear knowledge has been developed and accumulated over decades of research and development of nuclear technologies for power and non-power applications. Our present generation is the owner and custodian of that body of nuclear knowledge. Recent developments and policy statements of many countries indicate that nuclear knowledge will be needed in the future — most importantly for the continued use of existing nuclear power plants and research installations, but also for future innovations and for socioeconomic development. Unfortunately, the present status of nuclear knowledge and its management remain in an unsatisfactory condition. Since nuclear knowledge is unique in many ways, managing this knowledge requires specific programmes and needs to achieve specific objectives. Without diligence in managing this knowledge, substantial portions could be lost due to staff retirements as well as disuse and discard associated with changing priorities. Good management of nuclear knowledge, however, can contribute to economics, safety and innovation.

The present article describes the highest level issues and objectives for nuclear knowledge management that are commonly agreed to be relevant or applicable to activities in the nuclear sector as a whole, including power and non-power applications, and which are anticipated to be valid over a long period of time. Nuclear knowledge is a resource, with unique characteristics and requires an integrated and disciplined management, in order to maintain a high level of safety and economic efficiency of the nuclear activities involved.

The objectives and obligations for nuclear knowledge management as provided in the article address decision makers in Member State governments (including regulators), industry, R&D centres and academia concerned with nuclear issues.

KNOWLEDGE MANAGEMENT'S CONTRIBUTIONS TO MAINTAINING SUSTAINED NUCLEAR FACILITY OPTIMUM PERFORMANCE AND ECONOMICS

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Nuclear Knowledge Management (NKM) is a well-structured and focused management activity to fully utilize all relevant information and experience to ensure best possible Nuclear Power Plant (NPP) performance. NKM has recently been identified as a very important business process as a clearly defined and recognized part of NPP operations (see NEI Model describing business processes), which are required to ensure repeatable and sustained optimum performance and economics. The trigger to make NKM a "hot issue", was the challenge raised by the generation-shift, i.e., most NPP's are now getting 30 years old, and large numbers of the highly skilled and experienced work force are retiring during a relatively short period, and at a time when many NPP's get refurbished and re-licensed for another 20 - 30 years. Broad recognition of the importance of NKM has raised its status so that international conferences – like this one – are now dedicated to the subject of NKM.

This keynote presentation addresses the basic NKM concept and how it enables and contributes to the sustained top performance. Examples will be used to explain the large economic benefits of applied NKM, and also the large economic penalties that can occur when NKM is not used properly, or ignored, because it may not be recognized as an explicit and important management activity.

In relating to you these ideas, the following definitions need to be understood:

Knowledge = Information + Skill/Experience. It is not enough knowing the relevant information, knowledge means also having the skill/experience to use the information correctly in each work situation. This means relevant information and applying skills/experience are both required for any critical/important action taken.

Nuclear Knowledge Management = Continuous management process for insuring actions / activities are the most up-to-date and relevant for applying the information and skills (i.e., refreshment training) to use those resources correctly. Knowledge Management implies also that this is a repeatable process, which is measured (using suitable metrics) and adjusted by follow-up actions. Like all other management activities, NKM cannot be managed nor sustained, if it is not measured and followed up on. Ideally – there could be a manager who has responsibility for NKM (like each NPP has an IT Manager), alternatively – NKM is clearly described as a well-defined responsibility for each manager in a NPP. Today, it is still common, that NKM is left to individual managers using their own judgment, and not explicitly required by their job description nor measured. Exceptions are jobs such as NPP Reactor Operator Training, and Emergency Response Training, which are quite well-defined, regulated and monitored by US NRC's Reactor Oversight Process (ROP) Performance Indexes (EP01, EP02, EP03). In other words, measuring and monitoring NKM relevant to NPP Safety is "enforced" under NRC's ROP rules, while utilizing NKM to ensure sustained optimum NPP performance and economics is left to the plant owner's discretion.

Optimum Performance/Economics: By definition – can be achieved and sustained using NKM, i.e., if all NPP personnel at every point in time, have the most up-to-date and relevant information required for their tasks (best available industry information and OE), and also possess the required skills to carry-out each task correctly and efficiently. This is a necessary, but not sufficient condition to ensure sustained NPP optimum economics and performance, because having the best available information and the required skills / training does not automatically guarantee that NPP personnel always will utilize their knowledge (humans are known to sometimes act against better knowledge). For that reason, NKM needs to be complemented by a sustained good Corporate Safety Culture, and preferably Nuclear Asset Management (NAM), using real time data for measuring and condition monitoring performance degradation in all plant systems/equipment and critical components (except human performance) via a suitable software management tools.

Typically - each NPP has an IT manager, who is responsible for the capital investment in computer hardware and software, and that they are well maintained and upgraded as needed. This IT function and responsibility is - for obvious reasons - not distributed nor delegated to every manager in the NPP organization. For same obvious reasons, a NKM manager should have similar responsibility for the "human capital" involved in operating a NPP. However today, in many cases the HR department handles only the initial screening / selection of personnel that has the required knowledge and gets hired, but HR is not involved in the continuous "maintenance and upgrading" process, which is left to / delegated to the individual managers responsible for their personnel. In other words, HR departments are not practicing NKM (in spite of arranging occasional training classes in various subjects), and cannot be expected to replace a dedicated NKM manager function. Given the importance and economic impact of NKM, a special NKM manager function is well justified, to make sure that NKM gets the visibility and status in a NPP organization, which is needed to ensure that the benefits of using NKM can be realized and the penalties of not utilizing NKM (correctly) can be avoided.

NKM Benefits: The best example of a very successful early use of NKM in the Nuclear Industry is Outage Planning, and the best performing utility is TVO (2 x 840 MWe first generation ABWR's) in Finland, who has achieved 92-96% capacity factors and 14 days average outages consistently each year over past 20 years (10.6 days average in past 5 years). Compared to the typical 30 days outage length, TVO has produced an extra 4% electricity over the past 20 years, i.e, about 11 TWh. The success formula has been rigorous use of NKM principles (long before NKM was 'invented'): Typically about 1,000 people are working in an Outage. Each Outage task is broken down into its smallest "atomic" work elements that are stored in a "living knowledge" data bank (containing all up-to-date detailed information about each task, the pre-conditions, the skills required, qualified workers / mockup training, detailed timing, materials, equipment and tools needed, etc), and a sophisticated work scheduling software allows dynamic re-scheduling to avoid any wasted time on the critical time line. This is an example of NKM concept applied to its fullest. The 11 MWh extra production over two decades more than prove the value of NKM.

Maximum NKM benefits: The maximum benefits are obtained when this is applied to an entire NPP fleet. Potential annual savings are in the range of $4-6 million per 1,000 MWe output. This can be obtained by combining measured/monitored NKM for <u>all</u> NPP activities carried out by NPP staff, combined with Nuclear Asset Management (NAM), which measures and monitors all plant hardware conditions and performance degradation using real time data.

Not using NKM correctly can be costly: It is easy to find examples of the cost of not having a functional NKM process in place, either because of 'poor' organizational implementation of the NKM function, or absence of measuring and monitoring it's effectiveness, and thus not knowing "when it's broken". A very recent example is the

July 25, 2006 Forsmark-1 station blackout incident, the impact of which will be felt for quite some time by many NPP's worldwide. It's estimated direct cost (balance sheet impact) to the owner utility Vattenfall is over a $100 million and counting, but the cost of irreparably damaged public opinion is much higher still. The fallout from this incident has forced all NPP's in the Nordic countries to investigate and in some cases to shut down their reactors for up to 6 months (Oskarshamn-1). The root cause of this incident is a clear breakdown of their NKM process, which means that the lessons from some pre-cursor events in Germany and the identification of the same problem in Finland (TVO) five years earlier, was not acted on correctly at Forsmark, which was until last year's incident, the best performing Nordic NPP site in all categories for over a decade, with Safety Culture Indicators better than ever (i.e., giving no forewarning).

An even more costly lesson of having a 'dysfunctional' NKM process was learned in Japan by TEPCO, who had to shut down its 17 BWR's for over a year, after discovery of extensive falsifications of NPP inspection records. The Japanese NPP's certainly have a highly trained/skilled and motivated workforce with highest quality always on their mind (cf. famous Japanese quality standards in all other industries). However, one can observe that the NKM process did break down for 'known' culture-based reasons, i.e., the deeply rooted Japanese "aversion to report any negative findings" to superiors and upper management. In spite of all the training and knowledge, quality-mindedness, the cultural mental block was stronger, and in the end caused the NKM process to fail. A strong centralized NKM function may have been able to prevent this from happening (after all it was not a surprise really), and could have stopped it from going on for many years. The cost of this NKM failure is several billion US$, and the damage to public opinion is irreparable. The deadly JCO criticality accident (costing over a billion $) seven years ago happened due to the same reasons.

Other examples of extremely costly incidents that can be categorized as avoidable, if a robust NKM process had existed then and been in place: Browns Ferry-1, TMI, Chernobyl.

Conclusion: The on-going generation shift at the existing fleet of NPP's and also at reactor vendors, utilities and authorities, presents serious NKM challenges. In order to successfully overcome these challenges and to sustain the current excellent performance and economics of the existing NPP fleet in USA, Europe and Asia, it is mandatory to have a robust NKM process in place – preferably with high visibility and status in the respective organization, rather than spread out all over the place. NKM must be a highly focused and pro-active process, and cannot be a passive activity, or a NPP owner risks to lose a large amount of money before end-of-plant life, either by long term sub-optimum performance or worse still, a costly incident that could have been avoided. Good NKM by itself is not a sufficient condition to achieve sustainable optimum NPP performance and economics, but it is a necessary condition, without which a potentially costly incident is only a matter of time.

AN OVERVIEW OF KNOWLEDGE MANAGEMENT ACTIVITIES IN NUCLEAR POWER CORPORATION OF INDIA LIMITED (NPCIL)

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NPCIL's erstwhile corporate policy of knowledge management, for preserving existing knowledge and generating new knowledge for competitive advantage in dynamic business environment, needed a makeover to remain current with the changing international practices. A uniform and systematic KM approach at multiple NPP sites across the country, a few sites with multi reactor technologies (BWR, FBR ,PHWR & PWR-both old and latest) , needed to be evolved at the headquarters level and that too in a cost effective manner.

The key issues were:

- Development of new approach for human asset management - acquisition and retention
- Development and implementation of Knowledge Management (KM) systems, tools and programs for knowledge capture and dissemination
- Focus on generation, absorption and dissemination of new reactor technologies (700 MWe PHWR, FBR and PWR) knowledge bases
- Enhancement of effectiveness of KM systems/tools already developed
- Identification, career progression and redeployment of intellectual assets to organization's best advantage
- Making corporate information accessible to employee through knowledge portal, knowledge bank and sharing of best practices
- Harness IT infrastructure effectively for maximum advantage and to promote e-learning

In order to achieve above, across-the-board approach was adopted. A dedicated KM group under leadership of senior management personnel was created at HQs. As KM and learning activities for operating personnel were already streamlined, focused attention was given for qualification development for construction/project/engineering personnel. Committees and facilitator groups in the NPCIL Headquarters were constituted for finalization of qualification procedures.

A company-wide web-application called 'Corporate Human Asset, Review and Management System (CHARMS) has been developed and launched to capture, identify and map knowledge assets within the organization. The information captured on skill profile, area of expertise/interest etc was suitably integrated with job qualification requirement for finalization of employees' knowledge dissemination programs across technologies and processes. This has also helped organization in redeployment of personnel.

Knowledge up-gradation needs were compiled in form of a comprehensive list of about 300 programs .These have been categorized in four major categories like (i) core technical subjects (ii) techno-managerial and soft skills (iii) computer related skills and (iv) know your company/industry. Tacit knowledge capture, especially from experienced and retired personnel, through networking and incentives is also being attempted through experience sharing seminars. External faculties are also being invited for specialized courses.

Induction, training and placement processes for fresh engineers were revisited and revised. NPCIL collaborated with ‘Department of Atomic Energy’ towards development of post-graduate program in nuclear technology for engineers especially for those joining NPCIL. Networking with ‘Indian Institutes of Technology’ was strengthened for post-graduate programs through ‘DAE Graduate Fellowship Scheme (DGFS)’. In order to cater to need of larger number of engineers for expanding program of NPCIL, selection of engineers through prestigious Bhabha Atomic Research Centre Training School is being extended to NPCIL’s Training Centres located at five places across the country.

Many new projects towards work flow automation, specifically targeting training/learning processes, are being undertaken to capture undocumented explicit knowledge /convertible tacit knowledge. The major objective for such automation is to embed by Subject Matter Experts (SMEs) knowledge capture activities during execution of routine work processes so that the captured knowledge can be manipulated, transformed and disseminated through alternate KM processes. Typically some of processes such as engineers’ selection, induction training, placement, licensing & qualification have been fully automated. A web application titled ‘Glossary’ has been developed for unambiguous definitions of important technical terms used in NPCIL. Taxonomies for definition sources, references, related subjects, developer / reviewer references and such other are also being developed.

Web based application for managing work flow of licensing and qualification processes for operation and maintenance personnel of Indian NPPs called ‘Licensing and Qualification Information & Development System (LIQUIDS)’ is continuously fine tuned to capture problem solving /diagnostic skills. Formal on-job-training (OJT) is specifically embedded in LIQUIDS to promote mentoring and coaching through supervisors.

KM portal, a gateway to all knowledge repositories, has been launched. It provides interface to KM systems/ tools/programs/aids and facilitates involvement of ‘Subject Matter Experts’ for knowledge creation/transformation and knowledge sharing. KM portal is under continuous up-gradation

A project on e-learning for development of Computer /Web Based Training (CBT/WBT) has been launched. Technical Information Resource Centre, a repository of a wide variety of technical documents, e-books, reports and journals in electronic and physical form is being continuously strengthened. Reference document Section (RDC) which serves to retain/provide the archived reports, design documents and manufacturers’ manuals is also under up-gradation.

This paper summarizes the background, the present status, the experiences and the future plans towards Knowledge Management activities NPCIL, India.

KNOWLEDGE CAPTURE AND PRESERVATION AT CERNAVODA UNIT 2 PROJECT

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As it is known, Cernavoda Unit 2 - Romania, is a delayed nuclear power plant (NPP), started in early '80s, works were frozen in 1990 and resumed in 2003 under a management contract concluded by Nuclearelectrica, the Romanian nuclear utility, with Atomic Energy of Canada Ltd (AECL)-Canada and Ansaldo - Italy. This project has many specificities, **including long** time stored equipment, some works done 15 to 20 years ago; technology developments during these years; only couple of staff available from those initially involved; and a forthcoming project (Cernavoda Units 3 & 4) in its latest development phase.

On top of that, like in other Eastern European countries, Nuclearelectrica is losing people due to salary issue and "brain drain". In the actual international situation where the nuclear energy contribution to energy mix is under reconsideration and where the demand for qualified personnel significantly exceeds the offer, it is estimated that maybe the biggest challenge of the forthcoming Cernavoda Units 3 and 4 would be availability of human resources.

As Cernavoda Unit 2 Project goes towards a successful completion, all those who put lots of efforts and a difficult to overestimate contribution to overcome all challenges of this special Project will leave one after the other. Special attention is being given by Nuclearelectrica and the main contractors AECL and Ansaldo capturing the knowledge (both explicit and tacit) accumulated in these last almost five years and to leave to those who will continue the forthcoming Unit 3 &4 Projects and to the nuclear industry in general.

The objective on knowledge capture and preservation is to gather all experience and lessons learned during contracting, financing, constructing and commissioning of NPP Cernavoda Unit 2, with a focus on tacit knowledge and to asses potential improvements that might be applied in the forthcoming projects, in order to improve nuclear and economic performance.

There are couple of processes aimed to capture Unit 2 Project knowledge, including

Feedback control by/from Cernavoda Unit 2 Project: owned by the Project Management Team, it is a process under the control of "Discipline Manager" and "Division General Manager". It excludes any personal opinion tyoe of feed-back. Main topic covered include: design **technical**, design process, procurement process, contract items and systems.

Commissioning completion assurance (CCA) certificate: they are issued for a system or group of **systems** to provide **assurance that** each system has been adequately tested, its performance assessed to meet the design intent for a specified control point, and **succeeding** commissioning tests can proceed safely. Within this process specific attention is given to the problems discovered during commissioning and recommendations are **provided** for Units 3&4 in the commissioning report. The process is owned by the Commissioning Team **within the** project Management Team.

C2 Experience: owned by the Owner and intended to focus on all important topics in a NPP construction and commissioning project. In the **development** of database structure the IAEA-TECDOC-1390 was a valuable source of information.

C2 Experience is a small project specifically designed with a focus on capturing tacit knowledge. It is addressed to all managers from a certain level upward and senior specialists within the Project, who were invited to participate and provide their opinion on things that could be improved or streamlined on a number of 18 topics, including contract, financing, design, procurement, QA/QS, site infrastructure and IT tools. It consists in inputs provided in a web-accessed database specifically designed to provide a friendly user interface and in exit interviews with selected specialists. Minimising the time needed to input an information was a special request considering that the final stage of a project keeps very busy those requested to share project experience and lessons learned. The process is actually being implemented and completion would be after commercial operation.

After the finalization of the data input process, the information will be reviewed by a steering committee in order to filter out scam, etc. if any.

The main product of this process will be a database on Unit 2 Project knowledge structured on work break down structure, that could be easily sorted down on some key words like performance improvement, reduce cost/schedule. It would be of great value for the forthcoming project Units 3&4 allowing to streamline the difficulties caused by personnel turnover and to improve performance. It would be also containing valuable information for the nuclear industry in general and specifically to delayed nuclear projects.

REFOCUSING KNOWLEDGE AND INTELLECTUAL PROPERTY MANAGEMENT WITHIN THE UK NUCLEAR INDUSTRY

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The Nuclear Decommissioning Authority [NDA] was formed in April 2005 to take strategic responsibility for the UK's nuclear legacy. At this time BNGSL was given the contract, by the NDA, to manage and operate its Sellafield and Drigg sites in Cumbria.

Prior to April 2005, when these sites were owned and run by BNFL, the principal focus of Intellectual Property management was preventing competitors from copying BNFL's technical innovations and proprietary information. Today, in an environment where the NDA is focused on accelerating clean-up and reducing liabilities, through the application of appropriate and innovative technology, the role of Intellectual Property management has changed.

Under guidance from the NDA, BNGSL now aims to distribute rights to, and ownership of, Intellectual Property to whichever organisation is most likely to further develop the associated technology. The NDA has developed this Policy for two reasons. Firstly, this approach will incentives subcontractors to develop and bring forward new technologies. Secondly, by allowing subcontractors the freedom to use technologies, originally developed using NDA funding, for other waste owners the NDA anticipates that it will gain access to improvements, and where appropriate, a royalty stream.

To meet the NDA's expectations it is important that BNGSL's Knowledge and Intellectual Property Management operate as a seamless whole[1]. This need for unification is driven by a number of shared goals including:

The need to work with subcontractors to create an atmosphere of trust, and clarity of legal rights, so that information can be shared both up and down the supply chain.

The common interests of the KM and IP areas in improving the visibility of innovations created by BNGSL and its subcontractors, so that they can be shared and protected as appropriate.

A shared desire to ensure that commercially restrictive markings are only applied to truly sensitive information, so that barriers to the sharing of information are minimised, and commercial security can focus on a limited number of high value assets.

To facilitate the development of this integrated approach to the management of the Intellectual Property and Knowledge portfolio, BNGSL created in April 2006, a small central team to span both disciplines.

In June 2006, shortly after the formation of this new team the NDA commissioned a review of BNGSL's Intellectual Property management, while a similar exercise in underway to review its Knowledge management. In response, BNGSL is adopting six initiatives to advance the management of these Intellectual Assets.

Intellectual Asset criteria are being embedded within BNGSL's key decision-making processes. So, for instance, projects are increasingly being asked to prepare an Intellectual Asset Plan, which is then reviewed as part of the normal project approval process. Amongst a number of themes these Intellectual Asset Plans must include a) a search strategy describing; the databases, key words, people and communities that will be used to search for knowledge, best practices, lessons learned, technology innovations, etc. b) a description of the commercial relationship with any subcontractors and an analysis of how Intellectual Property rights are to be distributed in order to encourage subcontractors to bring forward new technologies.

A suite of Intellectual Asset management tools are being created that can be applied, with or without the support of the central KM & IP Team, by BNGSL's Business Units. On the Knowledge management side these include audit tools, peer assist methods and post project reviews. Intellectual Property management tools include database for tracking rights ceded to subcontractors, and an IT tool for approving the release of conference papers.

A clear Policy and Accountability framework has been created to provide transparent ownership of the challenges facing the management of these Intellectual Assets.

KPIs are being developed to match this accountability framework; so that goals can be set and the performance of all the NDA's site management companies compared.

Communities of Practice are to be formed in a range of areas including the Intellectual Property and Knowledge management disciplines. As part of their remit these two CoPs will review the performance of the NDA's various site management companies using the KPIs referenced above.

Ad-hoc reviews are being carried out to identify systemic problems with BNGSL's processes, systems and working practices and hence enable the preparation of an enactable Intellectual Asset management strategy[2].

This integrated approach to Intellectual Asset management has been chosen as it will better; leverage existing business processes, identify and build on existing best practice, and help link initiatives already taken by BNGSL's businesses to share knowledge and expertise.

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NUCLEAR KNOWLEDGE MANAGEMENT IN JAPANESE NUCLEAR INDUSTRY

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Various nuclear knowledge management (NKM) activities are ongoing in Japanese nuclear industries, aiming at safe, reliable and economical operation of nuclear power plants.

In most countries, except in the U.S., only one electric power company owns national nuclear power plants. In Japan, however, there are “many” electric power companies in the BWR and PWR lines. It tends to hamper smooth technology exchanges and data accumulation between them.

Recently, knowledge information flows are blocked and stagnate between electric power companies. This can be attributed to the intensified consciousness of protecting their intellectual properties, in response to the liberalized electricity markets.

Stagnant information flow may have adverse impacts on maintaining safety, reliability and economy of nuclear power plants. To cope with this risk, a proactive mechanism is needed for sharing relevant information.

Top management of electric power companies should consider institutionalizing a system for nationwide data collection, analysis and feedback, recognizing that NKM is more important than the protection of intellectual properties.

In the U.S., a dedicated entity, INPO, is collecting nationwide data for analysis and feedback. Japan has founded recently a new organization similar to INPO, as JANTI (JAPAN NUCLEAR TECHNOLOGY INSTITUTE).

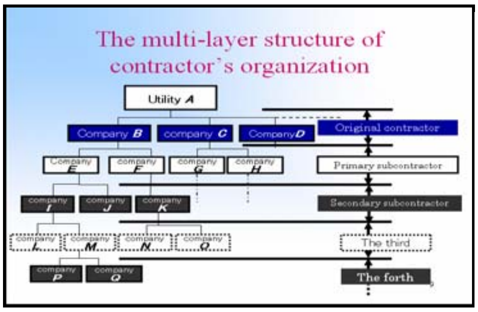
The NKM by the electric power companies will depend on their organizational structures of maintenance work.

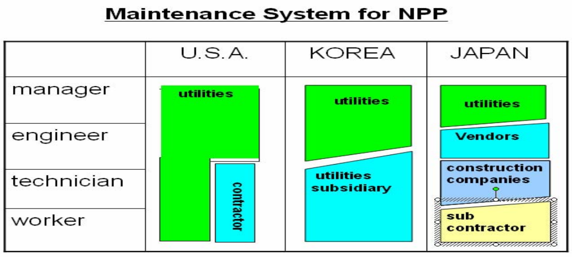
Let me elaborate further on this point by comparing organizational structures of maintenance work in several countries.

Organizational structures of maintenance work can be grouped into two types: by “own staff” or through the “contractors.”

Most countries have practices of managing the plant O&M work directory by the own staff of electric power companies.

One feature to note about Japanese nuclear industries is that electric power companies are outsourcing most of their maintenance work of nuclear power plants to multi-layered contractors.





The multi-layered contractor type has advantages in economics. Electric power companies can use cheaper workforces of small sized companies, as needed during the outages in the limited term span. This system is beneficial to the electric companies and the reactor vendors, allowing them to recruit technicians and workers, as needed for the periodical inspections.

In contrast, the direct employment type gives a heavy burden to the electric power companies due to long-term (life time) employment with a penalty of high wages and education/training costs.

But from the NKM viewpoint, the "contractor type" has a disadvantage to reserve experienced workforces for accumulating knowledge. NK might scatter and be lost in economical condition changes. The "direct employment type" is effective in accumulating relevant knowledge.

Too much outsourcing is not only dangerous for NKM but also loses its economical advantages of the "contractor type" by duplicated management staff.

U.S. electric power companies, which adopt the "direct employment type," is making efforts to level the annual workloads by an alliance with other nuclear utilities or by shifting some of maintenance workloads from the outage to the in-operation periods. Thus U.S. electric power companies are trying to compensate disadvantages of the "direct employment type."

In France and Korea, electric power companies are shifting their direct employment type to the contractor type. At the same time, they are trying to work out various ideas to cover the disadvantages of the contractor type. Recently, some of Japanese electric power companies are trying advanced challenges to fight with the disadvantages of their traditional multi-layered organizational structures of maintenance work.

OECD/NEA DATA BANK AND NUCLEAR SCIENCE ACTIVITIES IN SUPPORT OF KNOWLEDGE PRESERVATION AND TRANSFER FOR INNOVATION

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The OECD/Nuclear Energy Agency Data Bank was established as an institution for the collection, verification, validation, and dissemination of the basic tools used today for nuclear energy system design and simulation under different operating conditions. These tools comprise standardized databases with microscopic nuclear and chemical thermodynamic data, computer programs covering a wide range of applications, as well as information and data from integral experiments on fissile material systems, on reactor and radiation shielding mock-ups and on in-core fuel behaviour. They are continuously improved through user experience and feedback.

The OECD/NEA Nuclear Science Committee (NSC) has identified the importance to establish international experiments databases, and is working in close collaboration with the Data Bank concerning the compilation, verification and dissemination of the compiled data. The main objective of this data preservation activity is to minimise the risk of losing highly valued knowledge developed in member countries, and to prevent additional costs to future generations should they reopen the issue of the development of similar nuclear systems. By fostering the current work, the Data Bank will become a center providing its members countries with a solid reference on which to base their future work.

The collected information is preserved in an agreed standard format in computer accessible form. for use in the validation of current and new calculational schemes, for assessing uncertainties, confidence bounds and safety margins, and to record measurement methods and techniques. Training courses and workshops are mechanisms used for transferring the Data Bank's accumulated knowledge through world-wide participation of experts.

The databases established so far cover the following areas:

- EXFOR and CINDA (experimental neutron-and charged particle induced reaction data and their bibliographic index with over 123,000 experiments from 70 years of nuclear research)
- EVA (evaluated nuclear data libraries with all the main general and special purpose libraries, such as JEFF, ENDF, JENDL and BROND)
- Computer Program Library (computer codes covering a wide range of nuclear applications, about 2000 computer codes)
- ICSBEP (International Criticality Safety Benchmark Experiments Project Handbook, containing configurations with different combinations of materials and spectral indices)
- IRPhE (International Reactor Physics Experimental Benchmarks Evaluation Project)
- SINBAD (radiation shielding experiments, encompassing reactor shielding, fusion blanket neutronics, and accelerator shielding)

- IFPE (International Fuel Performance Benchmark Experiments)
- SFCOMPO (Spent Fuel Isotopic Composition data)
- TDB (Chemical Thermodynamics Database in support of Radioactive Waste Management)

The proposed paper will cover a brief description and the scope of each database, the methods used to standardize their compilation, and the importance of the evaluation, verification and peer review processes. The role of benchmarking will be explained, as well as the maintenance activity base on feedback from users and the continued improvement of the data through their use with new state-of-the-art computational methods. The data preservation methodology used will illustrate the importance of preserving measurement technology and techniques and the ensuing data evaluation processes. The role of training courses, using the databases and computer codes as a tool for knowledge and competence assessment of newcomers in the field, will be addressed. Finally, the programme of future activities will be described.

INITIATING THE KNOWLEDGE MANAGEMENT JOURNEY IN THE MALAYSIAN NUCLEAR AGENCY

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In 2002 MINT, as the Malaysian Nuclear Malaysia was called then, started thinking about knowledge management (KM) and held a workshop to introduce it to the top and middle management. Some people were impressed and started to learn more about it through training or their own reading and then started KM initiatives in their own group. It was not until the middle of 2005 that a formal KM strategic plan was formulated and endorsed.

At the end of 2006 an assessment of the KM implementation was conducted using the Knowledge Management Diagnostics (KMD). An overall score of about 60% was achieved. As the organizational average of 57%, this is considered not much of a success.

On analysing the situation and comparing it with some case studies, the following observations were made: 1) The KM program was implemented organization wide and this is too big a group to start of with, 2) The implementation did not involve the middle and frontline managers but instead operated through the steering and implementation committee, 3) There was no KM system or tools to facilitate the KM activities that were planned, 4) The activities that were initiated were too mild, unnoticeable and could be easily avoided, 5) The KM performance objectives such as what knowledge must be managed and the performance indicator were unclear, 6) the number of users of the intranet portal was rather low and its use does not seem to increase organizational value, 7) the KM policy lacks reciprocracy and does not support a covenant between the organization and its members.

To rectify these flaws, the following actions are taken: 1) Implement KM in just one program as a pilot and the Technical Service Program was chosen for this, 2) Form KM team comprising of divisional and group level focal points, 3) Conduct a user requirement survey to determine what data, information and knowledge must be captured, used, shared, preserved and measured and establish KM performance indicators, 4) Acquire KM system and tools that meet user requirements and fulfils most of the data, information and knowledge that they need to perform their work, 5) Put in place a KM policy, procedures and cultural norms that support a covenant between the organization and its members, where operating and espoused norms converge resulting in a high-trust environment.

The KM team comprises of divisional directors, group managers, practice leader, coach or facilitator with the Chief of the program acting as the KM champion. The roles and responsibilities of each of the members are well defined.

The KM survey is conducted through questionnaires as well as interviews and meetings with all groups in all the divisions in the Technical service Program. It addresses questions like what do you do, what problems and issues do you face and how can KMS address these problems and issues. Briefing on KM were provided to familiarize the members with KM concepts, processes and benefits.

The KM System (KMS)- The KMS should make work more efficient and effective and encourage knowledge identification, acquisition, application, collaboration sharing, preservation and measurement. It should address the problems and issues faced by organizational members and provide the following functions-

1. for enhancement of intellectual capital, learning and competency building,for managing performance and improvement of operations and include managing lessons learnt, best practices, manuals and procedures, for sharing of knowledge,
4. for collaboration, for capturing and preserving information and knowledgefor transferring expert knowledge,
7. for meeting daily needs such as leave, training, service and claims application, guidelines, minutes of meetings, schedules, etc, and
8. for providing organizational intelligence

Maintaining a KM policy, procedures and cultural norms that support a covenant between the organization and its members, where operating and espoused norms converge resulting in a high-trust environment requires that the organization provides adequately tools to access, manage and us knowledge, establish an environment that stimulates learning and creative use of information, create a culture of contribution and support the contribution process through roles and structure.

Another assessment using the KMD will be conducted in May and hopefully the actions that are taken would improve the state of practice of KM in the Malaysian Nuclear Agency.

KNOWLEDGE MANAGEMENT IN JOSÉ CABRERA NUCLEAR POWER PLANT

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As a consequence of the completion of José Cabrera Nuclear Power Plant (JC NPP) exploitation license, in April 30th, 2006, the installation began the "transition period to dismantling", with the main objective of fit out the installation for the transference to ENRESA, company in charge of the final dismantling.

The new situation of the plant, with very different objectives, has required a very wide change in all levels, with very different license documents, and with a different organizational structure adapted to the new position and function necessities.

In this change process, our Organization recognized the Knowledge Management (in a close collaboration with training) as one of the most powerful tools to face the new challenges. Due to this, it was our priority the adequate transmission of the associated knowledge to any position, to the new agents. This is extremely important, assuming the Organizations as a group, in which the knowledge of the group if significantly bigger than the addition of the individual knowledge, due to synergy processes.

Knowledge Management is the collection of processes and systems permitting that the intellectual capital increases significantly, through the efficient management of the problem resolution capabilities (in the shorter time), with the final objective to generate competitive advantages.

In the changes performed in an Organization, it is always present the risk of losing capabilities. It is fundamental to be capable to detect those capabilities and to control and retain them. The Organization has to set out the weaknesses and strengths associated to the change, and have to act in order to promote ones and erase others.

In the JC NPP, the preservation of this knowledge was probably the most critical point we have faced, due to the sudden plant shutdown. In a very short time, many organizational changes have occurred (both, in case of people leaving the plant, and in case of function redistribution), cause by the specific situation of the installation. The challenge was the detection of the "knowledge" arising in every situation, and the defining of the tool to keep it inside the Organization. The target was the development of the adequate environment and tools, to achieve the collaboration and support of the main part involved in the process, the employees. Also, we had the condition that every tool used, would have to be compatible with the short period of time available from the planning of the organizational change to the implementation.

Two kinds of knowledge exist: explicit and tacit. The explicit knowledge is the one we can obtain in a clear way, it is written, it is familiar to you and you can explain it (documents, PC applications, …). The tacit knowledge is the one we implement mechanically, and you don't advertise the way that you do that. It is attitudes and tasks performed unconsciously and activities intuitively performed.

Tacit knowledge is very difficult to explain, but vital in the Organizations, because it provides a kind of behaviours that have been improving along time and they are close to the better way to perform it. If an Organization were capable of retaining that knowledge, could get the necessary added value to stand out from the competence.

In JC NPP, we set out two possible solutions: try to convert the most of the tacit in explicit, or perform adequate overlap periods between the two people involved in any position. First one was rejected because it would have required people in every task taking notes of everything during a long time in order to be able to taking down all the details. In JC NPP we didn't have time enough.

We thought that most effective knowledge management method, according with the special characteristics of the installation, was the second solution. We developed a set of documents supporting the whole process, in which we provided different formats trying to cover all the possible issues. This process involved in the same manner, the one leaving the position, the one getting the position, and the department manager, in charge of the supervision of the process from a more general point of view.

One of the main points for the right development of the knowledge management process was the implication of the Plant Management. From the beginning, they were conscious of the importance of the process and several times they declare it to the staff, giving priority to the activities related.

Nowadays, we can say that the results obtained in the adaptation of the Organization to the shutdown of the plant, demonstrates that we have achieved (in a high percentage) the keeping of the necessary valuables to appear inside the standards of effectiveness and competitiveness.

KNOWLEDGE MANAGEMENT IMPLEMENTATION ON THE RESTART OF THE NUCLEAR POWER PLANT CONSTRUCTION

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Restarting the NPP[2] construction after 10 years of inactivity is a process that involves many preliminary tasks associated with the transition period to get the project started again. Implementing a KM program during the preparatory phase motivates the personnel and facilitates the completion of these additional activities.

Human Resources Motivation: Manpower is the most critical aspect to consider at the moment of restarting the NPP project. The reduced engineering teams left at the NPP lost their motivation as a result of the absence of project requirements. These groups, which were responsible of key activities in the past, and now assigned to other tasks, must be reinserted to the schedule and functions required by the project management. Moreover, they constitute the core that would transfer knowledge to the future personnel. Therefore, it is a good practice to include these engineering groups from the very beginning of the KM development. It is proved that the participation of these groups in the KM design and definition, in the knowledge map building, in identifying the domains and performing critical knowledge analysis by means of workshops, and in meetings and individual interviews facilitates the reactivation of them. The demands from the Knowledge Management Project create a good atmosphere to stimulate sharing and competences development.

Capturing Experts' Knowledge. During the years of inactivity of the plant construction many professionals and specialists that belonged to the original project teams left the organization taking with them their data and information related to the project evolution, and valuable undocumented knowledge. Documented meetings between current and past experts, or through an Experts Consulting Group articulates this tacit knowledge, and provides a source of answers about previous situations, taken decisions and critical issues. Furthermore, implementing a feedback program prevents the risk of knowledge loss due to the retirement of personnel.

Organizational Culture: The implementation of a KM promotes a cultural change within the organization of knowledge sharing, transferring and benchmarking, and the recording of the best practices in a systematic process making a more effective project execution that gives it a corporate administration.

The IT Processes and Infrastructure Innovation and Improvement. The technical documents control (e.g. specifications, drawings, procedures, etc) is a relevant subject as it is not only good to make a more effective communication among the departments and external companies, but also to inform about the state of the engineering or the construction. Errors, inconsistencies, or wrong versions of documents could cause unnecessary costs, and the not fulfilling of the quality requirements or the regulatory aspects. Consequently, updating the Document Management System is one of the main tasks to be done due to the software and hardware evolution (e.g. the updating of the databases used in the past, new workflows and

[2] Nuclear Power Plant

methods for information distribution, etc). The implementation of a KM Portal provides an IT platform to implement collaborative tools such as discussion forums, virtual meetings, virtual training programs, among others.

In conclusion, the integration of a Knowledge Management to the Nuclear Power Project incorporates an essential strategic resource (know-how), and gives to the Project Manager additional tools that facilitate the planning, execution and control of the activities assuring, in a more efficient way, the achievement of the desired results.

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INTEGRATION OF KNOWLEDGE MANAGEMENT IN PLANT SUPPORT ENGINEERING PROCESSES AT TEPCO

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Knowledge management has not always been successful at TEPCO. There were many attempts to collect knowledge. But most of them did not keep initial momentum and eventually faded away. We realized that just collecting knowledge and placing it in shared media was not enough. Rather than collecting knowledge we should recognize the knowledge management as a process of knowledge expansion through the good use of it in business processes.

Share and good use of information, especially non-conformance and operating experience is one of the key success factors of plant support engineering. At the same time, kew knowledge is created and retained, and engineers are trained through the use of information.

Fig.1 shows how TEPCO integrates knowledge management in plant support engineering processes. Accumulated knowledge of non-conformance management experience and operating experience is analyzed to identify operation risks, review preventive maintenance effectiveness, analyse human performance strength and weakness, supply just-in-time caution report to operators, and store key issued in engineering notebooks to support safe operation of nuclear power plants. New knowledge is continuously created in the processes and retained in the support engineering organizations.

Just-in-time caution report system was designed to supply operators with concise summaries of past experience at a right timing in procedure reviews and pre-job briefings.

Plant technical support team has been creating engineering notebooks through its activities to support operation support organizations and maintenance organizations. The notebooks contain such information as important past experience, engineering bases, and tips for better works.

There are some key success factors we have learned.

Organization: Knowledge management should be aligned with important operation management strategy.

Work process: Use of knowledge should be integrated into daily work and its effectiveness should be measured using performance indicators.

People: Important corporate culture should be identified to encourage positive behaviours.

Soft and hard infrastructures: Good organizational networks and IT systems should be developed and maintained.

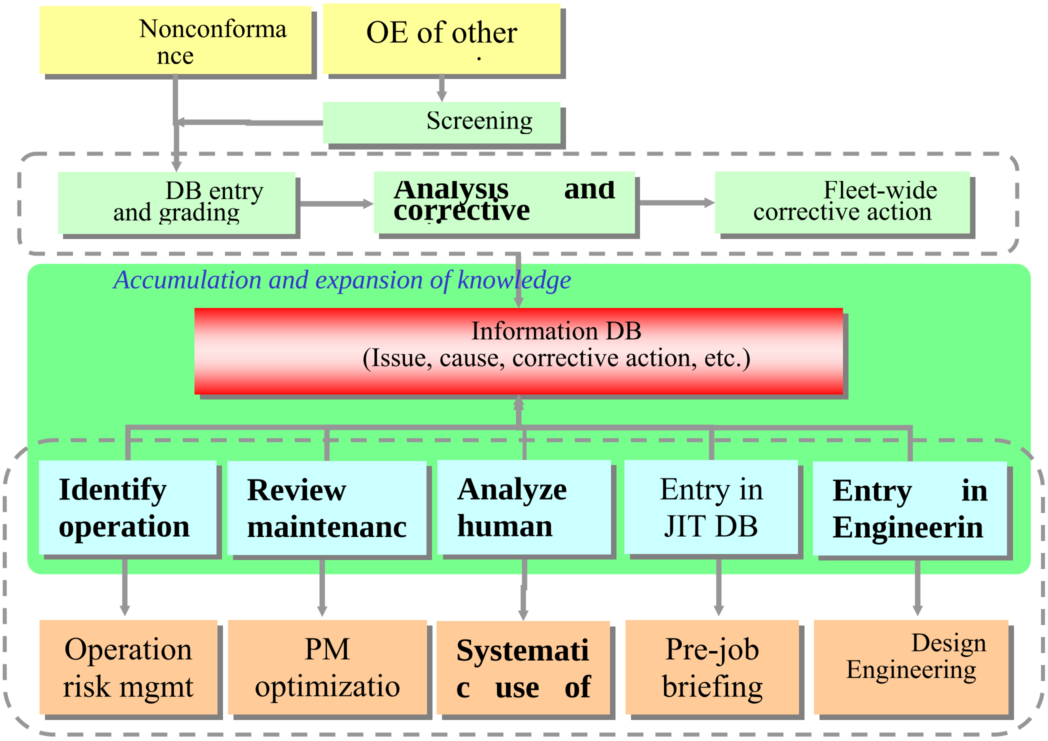

FIG. 1. Knowledge expansion through the use of nonconformance management experience and operating experience.

IMPLEMENTATION OF KNOWLEDGE MANAGEMENT IN THE DECOMMISSIONING OF NUCLEAR POWER STATIONS OF E.ON KERNKRAFT GmbH

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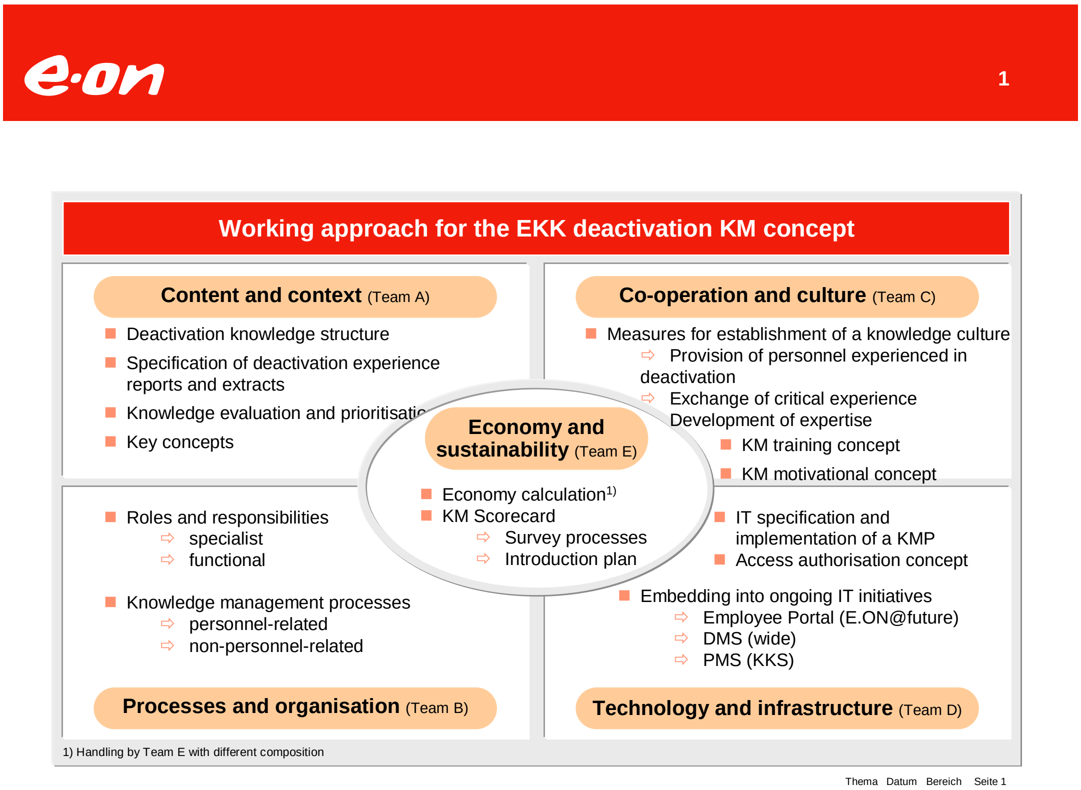
As the largest private nuclear power station operator in Europe, E.ON Kernkraft GmbH (EKK), in addition to the operation of such power stations, is also responsible for their economic and safe decommissioning. Nuclear power stations currently in the process of decommissioning include Würgassen (since 1997) and Stade (since 2005), with the objective of restoring them to "green field" sites.

A great deal of experience worldwide is now available on the decommissioning of nuclear power stations; EKK itself has also acquired experience in carrying out such decommissioning. In order to ensure the external and internal application of this experience, a project on the introduction of Knowledge Management was initiated in October 2002, and brought into regular operation in March 2004 [1].

Knowledge Management with regard to decommissioning is intended on the one hand to make the experience acquired with one plant available to the others, and on the other to collate and prepare the acquired knowledge for the benefit of future decommissioning projects within EKK. The overall aim is the economic optimisation of such decommissioning projects.



EKK currently has three years of practical experience in Knowledge Management, which can be divided into the following areas (in accordance with [2]):

Content and context

Knowledge Management with regard to decommissioning is divided into 12 areas. Various documents are being compiled and provided in each of these areas. Since the beginning, a total of approx. 500 documents have been prepared on Knowledge Management, of which approx. 100 have been compiled specially according to the specifications of Knowledge Management.

Co-operation and culture

In the field of Knowledge Management, regular meetings are held in which the experiences of employees on the corresponding subject (e.g. disassembly or radiation protection) are exchanged. Special services on Knowledge Management are introduced. A debriefing procedure has been successfully established for employees due to leave the company or a project.

Process and organisation

The Knowledge Management Organisation consists of local and central Knowledge Managers, persons responsible for a particular area of knowledge and providers and users of experience. A corresponding profile has been compiled for each role, and is currently being implemented by the specified role-holder.

Technology and infrastructure

The Knowledge Management Portal (WMP) as an SAP application has been selected as the IT platform. The WMP provides users with extracts and reports based on existing experience, together with further important documents and information. The WMP is today actively used by approx. 200 employees in Hannover, Stade and Würgassen.

Economy and sustainability

Two surveys have been held in order to obtain the opinions of employees on the quality and benefits of Knowledge Management for their work. Concrete measures have been developed and implemented as a result of the improvement suggestions. Since the start, the acceptance and use of the system has improved.

In summary, it can be said that Knowledge Management has been successfully introduced into EKK with regard to decommissioning. Significant positive effects are also anticipated with regard to decommissioning of further plants in the future. On the basis of these positive results, EKK also intends to introduce Knowledge Management in a modified form for other business processes.

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A KNOWLEDGE-BASED DECISION SUPPORT SYSTEM FOR EFFECTIVE PLANT OPERATION

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Effective management of plant ageing requires the timely detection and mitigation of ageing-related degradation of systems and components that are critical to the plant achieving its production and safety reliability targets. Organizations such as the Institute of Nuclear Power Operations (INPO), Nuclear Energy Institute (NEI) and the International Atomic Energy Agency (IAEA) have produced guidance documents to assist nuclear power plant (NPP) operators to develop equipment reliability and maintenance programs to achieve high levels of safe and reliable plant operation [3,4,5]. Implementation of these programs, however, requires the gathering and organization of plant data from a variety of sources to assess the current plant condition, identify and interpret deleterious ageing trends, and decide on the most cost-effective mitigative action. This can be a significant challenge to engineers in NPPs who lack the tools for gathering, organizing, analysing and interpreting plant data, and for assessing the impact of current conditions and trends on future reliability and performance.

This paper describes a knowledge-based decision support system developed by Atomic Energy of Canada Ltd. to enable plant engineers to quickly identify and diagnose problems before they have an impact on performance, predict the impact of current conditions on future performance, and manage the health of systems and components that are critical to plant safety and reliability. The decision support system facilitates all aspects of the decision-making process by gathering data from various sources, organizing and presenting the data in a way that makes interpretation easy, and interfacing it with diagnostic tools and predictive models to support making proactive and informed decisions. The system is centred on an information exchange portal that links monitoring and inspection results with maintenance records, equipment databases, event and alarm notification, and reliability reports in a way that is customisable to the needs of the individual user.

Examples of performance improvement achieved as the result of implementation of the knowledge-based decision support system will be given in the areas of chemistry management, equipment reliability and performance monitoring, inspection of critical components, fuel performance management, and plant configuration management.

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COMPETENCY DEVELOPMENT INFORMATION SYSTEM - KNOWLEDGE MANAGEMENT BASED COMPETENCY DEVELOPMENT MANAGEMENT TOOL

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Knowledge identification, acquisition, sharing, preservation and measurement are some of the desired habits and processes necessary for knowledge management to be effective and contributes to increased innovation, organizational value, competitiveness and sustainability. . The knowledge workers in the K-economic era are expected to be an innovative knowledge professional who are capable of managing their own work as well as their own competency development. Organizations however need to provide an environment, tools and policies to support and encourage learning and knowledge acquisition in all forms, methods and approaches beyond what is traditionally done.

For an ordinary knowledge professional, he is only interested in developing the necessary competency to complete his assigned tasks and progress in his career. He would not be interested to learn and be lectured on knowledge management or learning principles and concepts. But for the organization it is not only important that its staff members understand and able to go through the process of acquiring the necessary skills to carry out their current and future tasks at the right time, but it has to ensure that what they learn or their individual knowledge is converted into organizational knowledge, utilised, shared and preserved. Hence it is important that tools are provided and policies are set in place to ensure that staff identify, acquire, utilise, share and preserve knowledge necessary for organizational sustainability and growth.

A Competency Development Information System was recently developed to address the issue of inculcating the habit of identifying, acquiring, utilising, sharing, preserving and measuring knowledge among staff members hands-on by doing and repeating without having to learn the theory first. Besides that it helps organization manage competency development processes from analysis to planning, implementing and right through to evaluation.

The process starts from capturing information on business or division level mission, vision, objectives, strategies, projects and activities. From here the desired competencies are identified and broken down into knowledge and knowledge content. From this process the organization knowledge taxonomy is derived.

The next process is the knowledge needs analysis conducted at group level and then at individual level. The level of all identified knowledge necessary to carryout planned projects and activities are assessed at group and individual level on a scale of 1-10. This process is conducted in a group lead by the group leader or manager. The knowledge profile that results is presented graphically and the knowledge gap that has to be filled through some learning initiatives is clearly portrayed

Having identified the gap, the next task is to identify the knowledge sources in the form of books, journal articles, websites, laboratories, experts, vendors, electronic media and organised training and these are keyed into the system.

At this stage individual staff would have enough information to plan his learning and knowledge acquisition. He would then plan his learning using the training plan module. He can learn through self directed learning or go for courses, seminars, attachments, scientific visit,or Masters and PhD. The time, place, budget and source of fund need to be determined. The staff biodata and development plan is also captured by the system.

After implementing the training, the staff must submit a report and lessons learnt to the system. The system requires that the supervisor evaluates the training effectiveness, reviews recommendations and lessons learnt that was submitted and support and facilitate application of learning and implementation of any useful recommendations as a result of the training

All the learning initiatives should increase the knowledge and competency level. This assessment is conducted on a regular basis to evaluate the effectiveness of learning initiatives and investment in human resource development. This system assess competency level on a scale of 1-6, 6 being expert level. It can compare assessment result made at different times to see the improvement that results.

There are 5 types of users or log-ins- administrator, staff, supervisor 1 (manager), supervisor 2 (Director) and supervisor 3 (top management)

This system can generate the organization inventory of competency, training master plan, repository of lessons learnt, staff training record, staff CV, directory of expertise and many more..

With the right policy in place and continuous use of the system staff, individually and in a group will be able to practice the act of identifying, acquiring, utilising, sharing, preserving and measuring knowledge and manage their own competency development. In time it would become their habit and the organization would then be able develop a knowledge management culture

This system was designed applying the knowledge management principles and developed in the .NET technology environment using visual basic programming language and SQL server software. It took almost a year to develop and test and was only recently launched.

EXPERTISE MANAGEMENT IN NUCLEAR ENGINEERING BUSINESS

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In a context of growth and important renewal of the teams (due to the workforce ageing), the Nuclear entity of Tractebel Engineering, which is strongly aware of the importance o maintaining critical knowledge, has set up a program of knowledge management explicitly aimed at training those new forces, improving the collaboration between colleagues and capitalizing on knowledge.

This paper addresses in a concrete way one of the actions carried out: the transfer of expertise. It presents the developed methodology, the results of the projects initiated since 2004 as well as the lessons learned.

This expertise transfer intends to respond to the problems of the departure of certain personnel who possess a critical expertise for the realization of the activities and at preventing the losses of competences worked out with the passing of years.

Even if there always has been some amount of informal transfer of expertise between seniors and juniors, it has appeared essential, since several years, to structure a process of knowledge transfer that would make sure that critical and strategic knowledge will be well preserved and transmitted so that know-how remains and renews itself. In addition this process contributes to make the teams aware of the importance for the company of the knowledge transfer and capitalization even if not directly related to workforce replacement.

A KNOWLEDGE MANAGEMENT JOURNEY AT BNG SELLAFIELD: CHALLENGES AND OPPORTUNITIES

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All organisations manage knowledge in some shape of form. Over the last decade BNFL and latterly BNG, has undertaken a number of business improvement initiatives, however it was not until the late 1990's that a formal integrative KM programme was sanctioned.

Great progress was made with the chief aims of a broadly based KM programme with setting up of electronic `team rooms', improved database searching and "Learning from experience" processes and an embryonic "yellow pages" system etc.

By 2001, following major reorganisations of the business, Knowledge Management was classified as a `Cross-business issue'. Consequently, the decision was made to withdraw the Group Office co-ordination and resourcing of Knowledge Management in BNFL. There were no further significant developments until 2006, when there was an explicit request from the Nuclear Decommissioning Authority (NDA) for all nuclear site license holders (including BNG Sellafield) to manage knowledge and intellectual property effectively (NDA, 2005; 2006a; 2006b).

This policy posed several challenges for BNG Sellafield:

- Demonstrating that knowledge and good practise was being leveraged not only at each nuclear site but across the whole of the NDA's portfolio of 20 geographically and organisationally separated sites.
- Demonstrating that the considerable body of Intellectual property and associated rights was being managed for the benefit of the nation and in such a way that promoted Innovation in an industry where increased competition was being encouraged.
- The plethora of conceptual frameworks and definitions of knowledge management suggested a lack of uniformity as to what constitutes knowledge management; let alone how to implement such a programme.

Our solution was to employ a knowledge transfer process from experienced consultants and trainers to an internal team charged with the implementation of knowledge management at Sellafield. Our brief was to design and deliver a two year programme that will enable our team to absorb new ideas, experiment with new practices and to learn collectively how to deliver an effective programme that meets the needs of our business for the immediate and the long-term future.

The knowledge transfer programme has three phases. Firstly, our aim was to establish what knowledge we need to manage. As knowledge management is a means to an end and not an end in itself, our aim is to only manage knowledge that impacts on our performance. Working with internal business units we sought to identify their key knowledge areas and then focus on how they might manage them across knowledge management's three key dimensions: proficiency, codification and diffusion (CEN, 2003, p13). This knowledge strategy process is critical in that it provides examples of how knowledge is currently being managed and evidence as to how further interventions may assist enhanced performance. Such a strategy acts as a platform for informed decisions as to the requirements for new tools and techniques and also ensures that corporate knowledge management activities as well as those supporting individual business units focus on results. One important lesson learned during this phase has been that the design of an appropriate governance structure for the management of knowledge, with its associated accountabilities, roles, responsibilities and competencies is not a trivial matter and required careful consideration of different models and their contextualization to our BNG environment.

The second phase places more emphasis on experimentation through pilot actions.[6] During this phase, the main focus has been on developing small-scale actions, the rationale for which have emerged from the strategy phase. We anticipate that we will be launching pilots in the use of Sharepoint Portal, designing effective corporate yellow pages, communities of practice and lessons learned systems. Our full paper will be able describe our approaches in more depth once our current strategy process is more complete. These actions represent opportunities to find out what works and what needs further fine-tuning and also to establish the type of conditions necessary for fuller-scale implementation.

A further opportunity exists in that all of our knowledge management activities are being developed within the EFQM Knowledge Management Framework (2005) that explicitly ties knowledge management activities into the EFQM Business Excellence Model. The KM Framework has five enablers: Leadership, Partnerships and Resources, Policy & Strategy; Processes and People. It was developed following studies in 1996 and 2002 undertaken on behalf of EFQM (EFQM/CIBIT, 2002). Such a Framework will enable BNG Sellafield to benchmark against other organisations using the Framework in the medium-term future. Its benefits also include a range of indicators mapped against the enablers that can be selected for measurement depending on the level of knowledge management maturity at any given point in time along our journey.

Future developments include the establishment of a National Nuclear Knowledge Forum that facilitates the sharing of knowledge, good practise and promotes effective Knowledge Management between all sites in the UK.

Our conference paper will be articulate the range of challenges and opportunities more fully and provide some lessons learned at that point in the journey.

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[6] At the time of this conference, we will be in the middle of this phase.

PORTAL PROJECT IMPLEMENTATION IN NUCLEAR MALAYSIA TO SUPPORT KNOWLEDGE MANAGEMENT ACTIVITIES

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In Malaysian Nuclear Agency (Nuclear Malaysia), a portal project initiative was initiated as early as the preparation of its specification in the middle of the year 2005. It took six months project development and implementation to fit into Nuclear Malaysia requirements. The overall project is divided into two types of portal implementation, namely, Internet and Intranet Portal.

The main objective of the portal project is to support knowledge management at the organizational level through the simplicity of content management system using web and open source technology. The portal project includes some features of knowledge management system such as online collaboration and communication, knowledge repository and document management. After few months implementation, we found that the number of hits by users in Intranet portal is still small. On the other hand, Internet portal still need to be improved on the design as well as the content.

This paper describes Nuclear Malaysia's experience in the development and the implementation of the portal project in terms of the preparation, approaches and problems encountered during the operation and implementation of the project. Several recommendations based on the experience gained toward a successful implementation of the Internet and Intranet Portal is discussed and to be shared for the benefit of other nuclear research institutes.

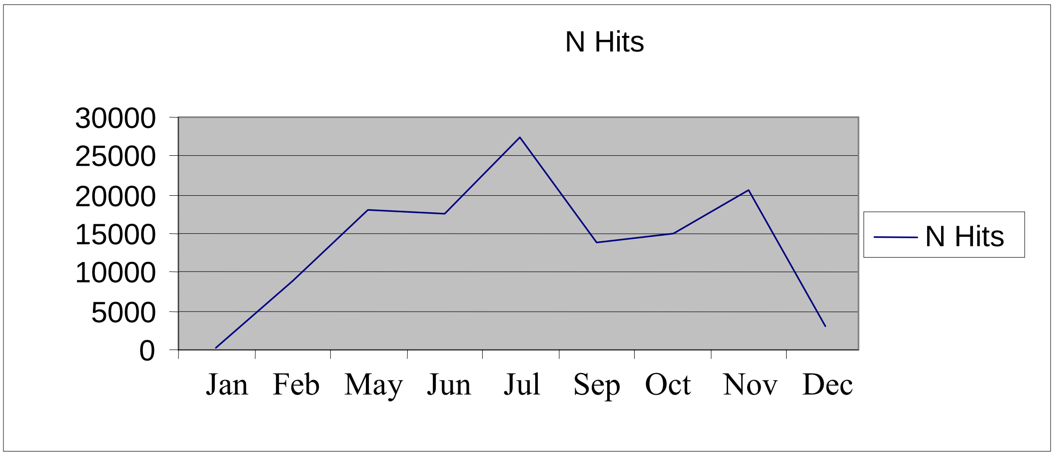

Figure1: Number of hits by intranet portal users in the year of 2006

KNOWLEDGE INTEGRATED MANAGEMENT SYSTEM FOR MAINTENANCE SERVICE AT NPP ISAR

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Maintenance has always been a key factor for successful operation of nuclear power plants. To improve maintenance decision making and to find an optimized scope of maintenance all relevant information needs to be collected and provided. Furthermore the systematic documentation and evaluation of maintenance results including the registration of maintenance know-how is an important step to close the maintenance process cycle.

AREVA NP and EON Kernkraft / NPP ISAR formed a cooperation aimed at the enhancement of the whole maintenance process. A knowledge integrated maintenance management method ─ supported by a dedicated IT- System (called WIS) ─ has been designed and implemented in the NPP ISAR since 2005. Since 2006 the same method is to be implemented at Volgodonsk NPP in southern Russia.

For a sound maintenance planning the system displays technical data and documents describing the maintenance histories of components as well as information obtained from condition monitoring equipment.

Specific maintenance instructions like dimensional records, checklists and tightening torques are directly stored in the WIS-System and linked to the corresponding components. Therefore maintenance documentation follows the structure of the instructions and is directly recorded in the system.

Finally the results are evaluated by the responsible expert. Conclusions on future maintenance actions, the suitability of the maintenance strategy and intervals will be drawn. Lessons learned from maintenance will be recorded in the system and assigned to all components concerned, as a contribution to plant lifetime management.

The WIS-System is meanwhile applied by plant personnel and contracted companies for all important components in several European power plants.

ENHANCING THE VALUE OF KM PROGRAMMES WITHIN THE NUCLEAR INDUSTRY THROUGH IMPROVED STRATEGIC FIT

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Designing and implementing a Knowledge Management (KM) programme poses the challenge of selecting an optimal mix of tools and techniques from the ever increasing range of related products and services offered by management consultants and ICT vendors. Strategic choices are required to achieve an effective portfolio of KM solutions and improve the value of KM to the organisation.

Many KM frameworks are available from national standards institutions and consultancy firms. Most of these offer useful support in mapping the KM territory, but few provide a detailed route map that will point the way towards strategic decisions relating to selection of KM projects and initiatives that make up a cohesive programme, nor do they provide guidelines for effective allocation of resources.

The nuclear industry offers additional challenges for the KM strategist, as many of the available frameworks are generic in nature and therefore do not take into account some of the issues and challenges that are specific to the nuclear industry. The need for engineering solutions with much longer life cycles and more deeply specialised areas of expertise often call for a different mix of solutions for knowledge transfer and preservation.

Prior studies [1] have demonstrated the importance of achieving strategic fit when developing a KM policy and related systems and procedures. The paper describes an approach that applies a 4-type model of organisational behaviour which takes into account entrepreneurial, organisational and technological dimensions. At a meta-level this approach enables differentiation between innovative units and those with stable processes and explores the corresponding differences in knowledge needs. This analysis can be applied to an organisation as a whole or to individual strategic business units, depending on the degree of heterogeneity of the organisation. Achievement of a strategic fit between the organisation's objectives and the KM strategy have been shown to have a major impact on overall organisational performance.

The paper examines how this approach has been applied within a major nuclear organisation in the UK. This supplements a process-based view of knowledge management [2] in which knowledge assets that support key business processes are identified and given particular attention within a KM strategy. Synthesis of top down and bottom up approaches help to provide knowledge alignment at all levels.

The strategic alignment approach helps to identify which areas of knowledge are most likely to bring business value to the organisation in terms of operational efficiency and effectiveness. These may translate into innovation and new revenue streams. In the context of nuclear decommissioning they are likely to lead to faster clean up at lower cost. This approach supports resource allocation decisions and helps to strike an effective mix of personalisation (people-based) and codification (document-based) strategies.

The paper provides guidelines for achieving strategic fit and discusses options for customisation of generic KM frameworks and their further development for application within the nuclear industry.

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A NEW TAXONOMY FOR CONFIGURATION MANAGEMENT: REQUIREMENTS, TECHNOLOGY, AND THE DESIGN BASES OF NUCLEAR POWER PLANTS

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A Configuration Management (CM) design has been developed that enables a new facility to apply the discipline of CM from the beginning of the design phase and manage it effectively over the life of the plant. In contrast to the historical practice of constructing a CM system from the existing databases and information systems, this proposed CM system has been designed from foundational principles identified in critical design and licensing documents. The proposed design reflects an emergent taxonomy of design bases that identifies critical attributes and incorporates the relationships between the physical plant, the design and licensing requirements, and facility documentation. Additionally, and perhaps most importantly, the design incorporates a design bases rule set to identify which design related information is required to be maintained within the CM system.

The development of this CM design involved the review of regulatory documents issued by the USNRC, starting with the definition of design bases [1] [2]. Regulatory sources were considered foundational principles. Industry guidance documents [3] [4] [5] provided clarification and examples of foundational principles from the regulations.

The foundational documents related to CM were analyzed to define taxonomy, i.e., a rigorous method to classify CM information. The new taxonomy was designed to impose consistency, repeatability and accuracy on CM information. The concept of a Design Bases Rule Set was established that contains criteria for determining what plant information is included in the CM system.

The taxonomy was tested using actual plant configuration information. Design bases and regulatory requirements were used as references to construct and complete the taxonomy. The reviewers on the team validated the taxonomy and the actual data for consistency, repeatability and accuracy.

Minimizing the cost of plant configuration changes is an important but secondary concern for future nuclear plants. The need to capture the knowledge of an aging workforce systematically while managing the fleet of reactors with fewer staff creates additional concerns that increase the desirability of a comprehensive CM process. But overall, the primary reason for designing a new CM system is the issue of nuclear safety. The foundational approach to CM described here affords a substantially higher degree of confidence in the validity and consistency of the managed CM elements. Safety confidence is further increased because of the higher degree of certainty that safety margins are being maintained adequately.

The taxonomy is represented in Figure 1 by a hierarchy of requirements and implementing documents successfully achieved the objectives of consistency, repeatability and accuracy.

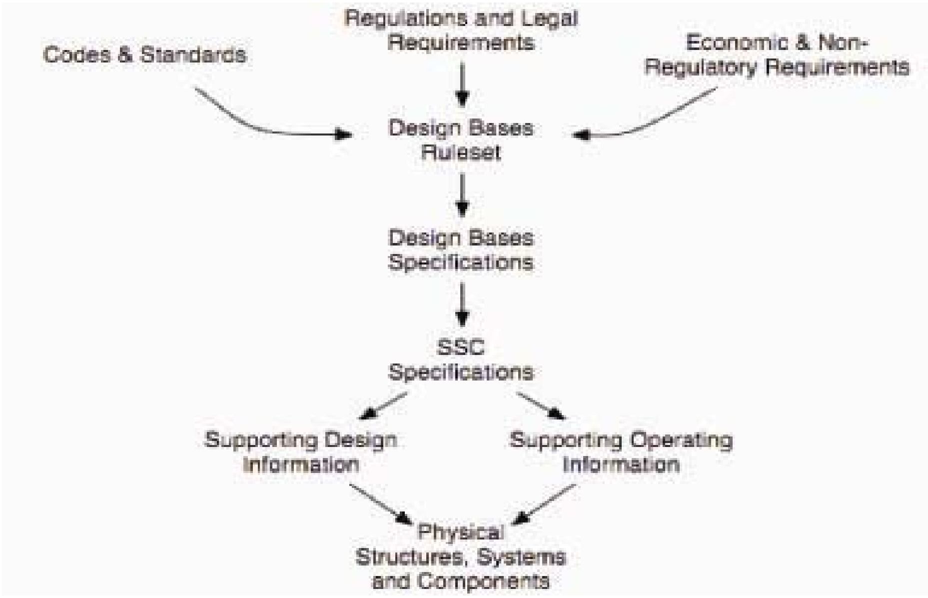

Fig. 1. Design Bases Taxonomy

This approach, intentionally hardware or software non-specific, will allow flexibility in documenting and maintaining the coherence of the physical configuration of the plant with the licensing and analytical bases, without regard to the mechanisms of execution. As coincident benefits, design bases margin management, calculation input and output management, and instrument set point management are all natural consequences of this taxonomy and are incorporated in the new CM design.

This new design for CM will enable a new facility to apply sound CM practices from the initial design phase and manage the relationships between the physical plant, the design and licensing requirements, and facility documentation effectively over the life of the plant.

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MAPPING NUCLEAR KNOWLEDGE DOMAINS AND DESIGNING KNOWLEDGE PORTALS

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This paper discusses the practical guidance for mapping knowledge and development of Nuclear Knowledge Portal.

We give three case studies of mapping nuclear knowledge domains: in a radio-pharmacy centre (CR) of IPEN ([Ricciardi and aI., 2006]) to build a coherent strategic plan for operational knowledge management of CR; in the IAEA Nuclear Safety and Security department ([S. A. Mallick, 2004]) to develop a Nuclear Safety Knowledge Portal to pool, analyse and share nuclear safety knowledge in GRS, to describe knowledge domains for knowledge maintenance and for structuring of an organizational knowledge portal ([D. Beraha et aI., 2006]). The different steps are described below.

Step 1: Construction of the knowledge cartography

A demanding problem is how to represent the organizational knowledge in a way that is both visually friendly and accurate. The approach used in these projects, named "Knowledge Domain Cartography", is based on a classification by domains, according to themes and finalities that was proposed, for instance, in [J-L Ermine 2003]. The construction of the cartography starts with a central node that corresponds to the main purpose of the organization. Then, a set of out flowing axes start from this node, each one representing a strategic knowledge theme, usually associated with a main components of the mission of the organization. Depending on the level of detail that one wishes to show, the main axes can give origin to secondary axes representing sub-themes and those originate branches to represent smaller knowledge domains, which themselves can be further split if convenient. The granularity of such process should stop at knowledge objects, whose labels are associated with concepts that are consensual to people working with that knowledge domain. Such concepts may provide the basis for other knowledge representation techniques such as the construction of domain ontologies by analysing their interrelations, properties and instances.

Step 2: Relevance or criticality analysis

The objective is to assess the relevance of each knowledge domain according to the objectives and goals of the organization and to find what is relevant or critical in each domain to cultivate a corporate repository. Several approaches were developed on the lines of the French model ([J-L Ermine 2003]). The CR project used evaluation general criteria that were aligned with goals and needs of the organization; two aggregate criteria were used to evaluate the relevance of the knowledge domains, and three criteria were chosen for vulnerability assessment. The Safety Knowledge Portal project defined pertinence criteria to evaluate already existing pieces of knowledge (essentially explicit, in more or less standards documents), in nuclear, radiation, and waste and transport safety. A several point scale was used in the evaluation for each criteria. Questionnaires and planned interviews were used to the analysis. The compound grade for relevance, vulnerability or pertinence was an average of its individual criteria. This methodology can be applied at various degrees of complexity and in-depth analysis.

Step 3 : Designing a Knowledge Portal for KM actions

There are many actions of the "classical" KM repertoire that could be suggested to leverage generation, sharing, utilization and improvement of the knowledge domains considered to be essential. The best choices depend on many factors such as the type of knowledge conversion, formatting and involved repertoires in each knowledge domain.

The identification, mapping and analysis that have been performed in those projects provided a clear perception of what are the critical knowledge domains to be managed, or what are the pertinent knowledge chunks to be disseminated.

The Knowledge Portal (KP) is the basic tool to design in the next step to support KM actions that have to be realised. It requires to develop a file structure that covers all major knowledge domains so that knowledge repository can be created in each knowledge domain, supporting every adequate KM action: access to pertinent documentation, to experts yellow page, to knowledge data base of "problems and solutions", to virtual communities of practice, to Best Practices, to an organizational memory (Knowledge Books ..); and so on. A knowledge portal is basically a centralized, fast and friendly access point to any knowledge a user may need. Usually this portal has to interact with a variety of file structures of multiple data bases across the organization and be able to provide access to knowledge object where it may reside. This should be done in manner that is transparent and logical to the user. Knowledge Maps are good candidates to provide a tagging system (of metadata) and a thematic navigation scheme to the KP that can accomplish such objectives, as indicated in the SKALTO project: Safety Knowledge Base on Ageing and Long Term Operation ([S. A. Mallick, 2004]).

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CASE STUDY: ATLANTIS SYSTEMS INTERNATIONAL – USING KM PRINCIPLES TO DRIVE PRODUCTIVITY AND PERFORMANCE, PREVENT CRITICAL KNOWLEDGE LOSS AND ENCOURAGE INNOVATION

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"Knowledge and information are different. You can manage information; you can't manage knowledge. However you can manage the process that converts information into knowledge. At Atlantis, we treat knowledge management as a construct of information management (product, content) and knowledge building (process, people)"

In 2003 Atlantis Systems International a 28 year old Aerospace engineering company was on the brink of insolvency.

While the company was a leader in providing simulation-based training products, their market share had decreased steadily over the past 3 years. This decline was due in part to uncontrollable external forces - The formation of the European Economic Union and the tragic events of September 11. Both events lead to restricted market access in the U.S. and Europe for Atlantis's products and services.

In addition to these external forces, the company experienced prolonged instability at the management level that resulted in a loss of key personnel to other companies. As no formal knowledge management processes were in place for capturing Intellectual capital, these employees took their knowledge and with them when they left the firm leaving critical gaps in knowledge base of the company.

For a company to become knowledge centric organization where knowledge is continuously captured and leveraged to drive innovation requires an understanding of the processes that convert information into usable knowledge. This is as much a social challenge as it is a systems or use of technology challenge. The central question the company or organization has to address is, "how do we get people (employees and management) to willing share what they know in order to grow the company?"

The type of organizational change is synonymous with building a "learning organization", but while this is certainly implicit, the term is sufficiently ambiguous as to include almost any activity where there is some transfer of information or knowledge - It does not necessarily produce innovation in the form of new products and services or in the continual improvement of work flows.

Innovation at this level requires the creation of a knowledge building culture where the explicit goal for everyone in the organization is to continuously build and contribute new knowledge to the benefit of both the individual and the organization.

By 2007, Atlantis revenues had grown by over 200%; the workforce increased from 102 employees to approx 210 employees; retention rates have remained consistent at 3% over a three year period, and the business has expanded its operations into the United States. In addition the company successfully leveraged its knowledge and expertise in training from the aerospace sector to enter the nuclear energy sector.

The paper will present a conceptual framework for understanding Knowledge Management as it relates to organizational development, change management and innovation. Using concrete examples over a 3 three period, it will describe how knowledge management strategies applied by Atlantis to increase performance and profitability, encourage growth, accelerate innovation, attract and retain key talent, prevent knowledge loss, can be applied to the address the looming ‘Grey Out” of the nuclear energy sector .

BENEFITS AND OPPORTUNITIES FOR APPLYING INTEGRATED MANAGEMENT SYSTEMS (IMS) STRATEGIES IN THE NUCLEAR INDUSTRY

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The safe, reliable, and cost-effective operation of Nuclear Power Facilities require a vast accumulation of information - volumes of scientific research, engineering analysis, operational data, regulatory reviews and many other types of technical information - combined with a complex assortment of people with the requisite educational background, expertise and acquired insight to apply that body of knowledge safely and effectively.

This paper is intended to address the changing strategies and deployment techniques of IMS by identifying and examining initiatives that have been instigated in other regulated (and non-regulated industries), analyzing the opportunities, challenges and success criteria.

"Virtually everything in business today is an undifferentiated commodity except how a company manages its information. How you manage information determines whether you win or lose." − Bill Gates, Microsoft

A number of independent studies have drawn similar conclusions as to the benefits of managing plant information:

The National Institute of Standards and Technology (NIST) estimates that \$15.8 billion in profits is lost in U.S. capital facilities every year. Most of these losses, (\$9.1 billion or 2.8% of total installed cost), are realized in the operations and maintenance phase of the asset life cycle, while \$2.7 billion and \$4.1 billion are realized in engineering, procurement, and construction (EPC) phases respectively.

It is clear from the report that again the O/Os bear the brunt of the costs (\$10.6 billion or 3.3% total installed cost) associated with poor information management (in this case interoperability) due to supply chain dynamics and duration, and that with proper incentives for their information supply chains, O/Os have the most to gain.

- 45% of costs are associated with operations and maintenance information verification
- 15% of costs are associated with unnecessary operations and maintenance idle employee time
- 40%, the balance, is an assortment of work process inefficiencies
- Though NIST's study was limited to the U.S., these opportunities are applicable to the rest of the world

Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry, Prepared for National Institute of Standards and Technology (NIST), report GCR 04-867, August 2004.

A second study analyzed the benefits that accrued from managing information in regulated facility/installations through the plant life cycle and came up with the following productivity benefits. When viewed holistically, an operator could reduce the whole life cost of the asset by 10%. Within specific life cycle phases, the following were achievable:

- Increase 30% engineering productivity
- Reduce 10-30% of concept development time
- Reduce 15-28% of engineering hours
- Reduce 10-30% cost of quality and change management time
- Reduce 15-20% commissioning engineering hours
- Reduce 60% handover and startup costs
- Reduce 10-20% IT costs
- Reduce 10-20% operational costs

POSC/Caesar for Better BUSINESS, SUMMARY REPORT, Prepared by: Coopers & Lybrand Consulting ANS, Oslo October 1997.

The electric power plant industry compared the benefits of "integrated information" to that of "automation tools" when developing and managing power plant assets where automation pertained to computerizing data and tasks for use within a single activity or department and integration pertained to computerizing data transfer among multiple activities, departments, or companies.

One of many examples cited was that of "Relative Annual Savings from Automation and Integration at an Average Nuclear Power Plant," which found:

"It can be concluded that the advantages of integration are significantly greater than those from improving the productivity of the individual tools by automation. "

The paper goes on to describe the effect on reliability, availability, and maintainability (RAM) by reusing the data more than once in other activities. For example, equipment valve specs and associated activities − including performance monitor, performance analysis, reliability assurance, reactor safety, incident investigation, industrial safety assurance and analysis, valve/valve operator maintenance, maintenance procedure development, equipment history analysis, operational procedure development, emergency operations, and operating experience evaluation − yielded an annual cost savings of $8,071,275 alone (in 1987)!

Guidelines for Specifying Integrated Computer-aided Engineering Applications for Electric Power Plants. Electric Power Research Institute (EPRI) report NP-5159M, Research Project 2514-3, May 1987.

These reports clearly conclude

- There are significant gains to be made across the whole life cycle, but the breadth of application sources, range of information types, classes of organization, and types of user and business processes would challenge the traditional "point solution" approach (classes of system required to solve these life cycle issues need to be extensible).
- Companies have "automated" individual task processes and are looking to "integration" in all its forms as the next level of business benefit. Integration will bring other challenges that are not wholly technology oriented since data flows across business function boundaries. Integrations will require you to understand the inputs and outputs, customers, and suppliers.

JOB AID METHODOLOGY: A CRITICAL TOOL FOR KNOWLEDGE TRANSFER

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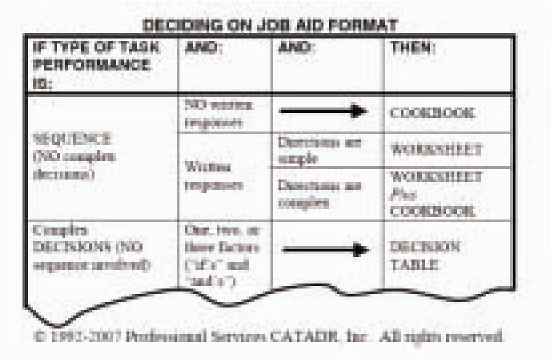
Expert Systems are Effective at Knowledge Transfer, and JOB AID Methodology is an expert system for designing expert systems.

- Job aids, which expertly produce expert systems, mitigate the effect of turnover and retirements from losses of “institutional knowledge.”
- Use of well-developed job aids produce exemplary performance at relatively low cost.
- Job aids greatly reduce cost of information development vis-à-vis training to memory recall.

Job Aid Methodology is revolutionary and unique in its capacity to convey expert knowledge to performers on-the-job. Job Aids are most significantly — on-the-job INFORMATION. A Job Aid represents a superior way to achieve performance improvement because it directly affects performance WHERE it counts — on-the-job — and WHEN it counts —at the time performance occurs. A clear definition of what a job aid is, and what one is not, is important to deciding when a job aid is appropriate.

JOB AID Definition: A storage place for information OTHER THAN MEMORY which… is accessed in REAL-TIME ON-THE-JOB; is written at a level of detail to minimize trial and error; reduces necessary amount of recall from memory; and gives directions on WHEN and HOW to perform.

Job Aids are superior guidance information when high complexity tasks are being performed, low frequency or unpredictable frequency tasks are performed, or especially when tasks carry important or devastating consequences; i.e., EMERGENCIES; and consequences of error are intolerable; e.g., airplane PRE-FIGHT CHECK LIST.


DECIDING ON JOB AID FORMAT

IF TYPE OF TASK PERFORMANCE IS:	AND:	AND:	THEN:
SEQUENCE (NO complex decisions)	NO written responses	→	COOKBOOK
	Written responses	Directions are simple	WORKSHEET
		Directions are complex	WORKSHEET *Plus* COOKBOOK
Complex DECISIONS (NO sequence involved)	One, two, or three factors ("if's" and "and's")	→	DECISION TABLE

The possible FORMATS for a Job Aid are Cookbook (checklist is special type of cookbook), Worksheet, Decision-Table, Algorithm, or Combination of these.

Job Aid Methodology is a SYSTEM that is SYSTEMATIC:

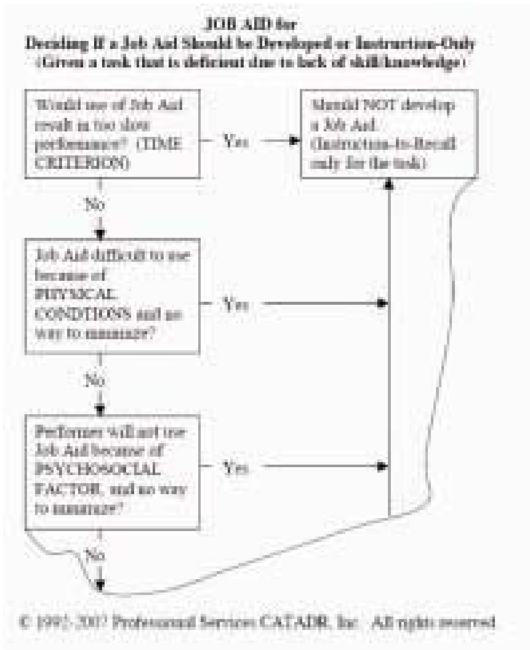
- A systems approach. The outputs of one phase become inputs to subsequent phases
- A systematic approach. As opposed to a random, eclectic, or “artistic” approach
- Grounded in a description and analysis of expected on-the-job accomplishments

- Front-end-loaded. Emphasis on analysis and design
- Derived from proven behavioural theory producing logically consistent, accountable and reproducible results
- Decisions are rule-based with detailed algorithms and decision tables
- Provide unambiguous guidance on amount and type of detail required to produce optimum performance
- Designed to achieve maximum effectiveness AND efficiency
- Provide guidance on whether training support is needed
- Complete documentation: Job Aids, Worksheets, Training

Our research and experience has shown us that procedures, which are essential to effective knowledge transfer, are not often based on comprehensive, systematic methods. Where such methods may exist, they are inconsistently utilized. By contrast, when the Job Aid Methodology is used to DEVELOP a procedure system, the result is consistently superior procedures which promote superior performance.

A Job Aid is ALWAYS a procedure; a procedure is NOT often a job aid. We have found that procedures and procedure policies often

- focus on format and style, not on effective content which conveys knowledge;
- do NOT make the overt decision on procedure vs. training;
- are not accessed in real time;
- rely heavily on memory recall rather than access to documented information;
- vacillate between high and low detail to compensate for perceived cause of performance error;
- do NOT match the behaviour characteristic to the information format (i.e., sequential behaviour should be a sequence in a cookbook, checklist, etc.; a decision should be a decision table or algorithm; and so forth.);



- are ambiguous with regard to level of detail describing performance; and
- constrain formats with boilerplate that is cumbersome and confusing

Adopting the Job Aid Methodology corrects these procedural system shortcomings and substantially improves knowledge transfer.

COMPETENCES AND LIFE MANAGEMENT PROGRAMMES

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The nuclear industry is, at present, at a crucial juncture, where it has to decide about the future of the first generation of nuclear plants, which are approaching the end of their licensed service life. At the same time, long term experience and new advances have established that it is possible to extend the life of nuclear plants beyond their initially licensed life by another 20-30 years. Extending the operating life of existing nuclear plants will help to reduce the short term need for new generating capacity - without new capital costs. However, these extensions must take place in the context of careful safety analysis and monitoring of equipment ageing concerns.

A nuclear power plant must be managed in a safe and efficient manner throughout all the life cycle stages from design through decommissioning. The consequences of management decisions about nuclear power plants can have profound economic impacts for the nuclear power plant owner, and possibly for the national economy. In addition, the consequence of a major failure or accident can have catastrophic national socio-economic effects that may be felt internationally.

The safe and effective management of a nuclear power plant therefore requires dramatically different perspectives in time from the majority of other industries. The impact of some decisions extends beyond the normal strategic perspective of both owners and governments.

The integration of activities for ageing management, safety management and business management of a nuclear power plant are an essential element of "life cycle management".

The loss of information at any stage of a nuclear power plants life deprives people, at later stages, of knowledge that could be important to safe, economic completion of work or which could aid the analysis of problems and options. It is costly to go through the learning process again, with a risk of potential events or incidents, programme delays, physical injury and increased regulatory surveillance. In some cases, it may be impossible to rebuild information. As a consequence assumptions may have to be made that cannot be easily substantiated.

It is therefore essential that the strategies for plant life management are developed with sufficient clarity to enable the associated human resource strategy or long term Human Resources plan to be developed. This strategy/plan should be reviewed and updated periodically to verify that it is consistent with and supports the nuclear power plant life cycle needs.

In this work we analyze the competences of young peoples for working in the Life Management and Life Extension of Nuclear Power Plants Programmes..

Competences and skills are understood as including knowing and understanding (theoretical knowledge of an academic field, the capacity to know and understand), knowing how to act (practical and operational application of knowledge to certain situations), knowing how to be (values as an integral element of the way of perceiving and living with others and in a social context). Competences represent a combination of attributes (with respect to knowledge and its application, attitudes, skills and responsibilities) that describe the level or degree to which a person is capable of performing them.

In this context, a competence or a set of competences mean that a person puts into play a certain capacity or skill and performs a task, where he/she is able to demonstrate that he/she can do so in a way that allows evaluation of the level of achievement. Competences can be carried out and assessed. It also means that a normally person does not either possess or lack a competence in absolute terms, but commands it to a varying degree, so that competences can be placed on a continuum.

The following was taken as a working classification:

— ***Instrumental Competences***: Those having an instrumental function. They include:

- *Cognitive* abilities, capacity to understand and manipulate ideas and thoughts.
- *Methodological* capacities to manipulate the environment: organising time and strategies of learning, making decisions or solving problems.
- *Technological* skills related to use of technological devices, computing and information management skills.
- *Linguistic* skills such as oral and written communication or knowledge of a second language.

— ***Interpersonal Competences***: *Individual* abilities relating to the capacity to express one's own feelings, critical and self-critical abilities. *Social skills* relating to interpersonal skills or team-work or the expression of social or ethical commitment. These tend to favour processes of social interaction and of co-operation

— ***Systemic competences***: those skills and abilities concerning *whole systems*. They suppose a combination of understanding, sensibility and knowledge that allows one to see how the parts of a whole relate and come together. These capacities include the ability to plan changes so as to make improvements in whole systems and to design new systems.

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A PRAGMATIC APPROACH TO CONDUCTING KNOWLEDGE AUDITS

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An important component of any Knowledge Management strategy is the Knowledge Audit. A Knowledge Audit involves the collation of an inventory of knowledge resources or assets [1] in a given working environment. Such an audit can be carried out at various levels within an organisation, e.g. within a particular business process, a department, a function, or across an entire organisation. Commonly there are a number of ways of carrying out a Knowledge Audit, including for example survey, interviews, or business process and documentation analysis.

As with any audit activity, key to the Knowledge Audit is having a well-defined scope. A Knowledge Audit, for example, may seek to understand current knowledge resources; the nature of that knowledge in terms of its format, its location; and the individuals or communities within the organisation that hold that knowledge. In addressing these aspects the audit may act as the baseline, or reference point, from which subsequent Knowledge Management strategies may be employed for example, the setting up of 'Communities of Practice', or the development of IT based systems for disseminating knowledge).

This paper describes a workshop-based approach to carrying out a Knowledge Audit derived from experience of conducting a number of information audits within the Environmental, Health, Safety & Quality (EHS&Q) function within British Nuclear Group Sellafield Limited (BNGSL) in the UK. The approach, involving facilitation of teams of 'experts' has been developed over the past 2 and a half years. It has been applied in 2 main contexts to date; in records management and records identification; and in the context of an Intellectual Property (IP) assessment. This paper proposes that the same approach, tailored to the specific context at hand, can also be readily applied in the context of Knowledge Audits (see Figure 1).

The paper will describe the key characteristics of the workshop approach. The overall aim of the workshops are that they should be a practical means to engage experts in the technical or business process under scrutiny. Involvement of experts not only provides an obvious source of information but also better enables a sense of ownership of the future development of information management strategies. The workshops typically take place over 1 to 3 days, depending upon the scope and complexity of the process being assessed. Each workshop commences with the attendees being asked to describe their process (es) in a series of process steps. Mindful that process descriptions can themselves take a long period of time to produce the emphasis, bearing pragmatic concerns in mind, is to arrive at a level of description that will at least provide a shared 'vocabulary' for the remainder of the workshop. These outline descriptions (e.g. title, sequence) then form the framework against which to capture further attributes or features of the process. The further process step attributes are defined in advance of the workshop and are determined by the overall aim of the audit. For example in the case of the Records Identification audit, attributes of the process included such elements as input/output documents, document format, and responsible person. In the case of the IP Assessment attributes of a process step included items such as (information) resources, (information) products, format and stakeholders.

A purpose built (Microsoft Access) database was developed to capture the output from the workshop. The database input forms were then projected on a overhead screen during the workshop. Use of a database had a number of advantages: it helped focus the discussions during the workshop; it reduced the amount of time spent writing up the output following the meeting; it provided a more flexible means of reporting the outputs; and finally it acted as a repository of information that can be maintained and updated as required into the future.

The paper concludes by summarising the overall benefits of the proposed approach based upon the actual benefits and successes experienced in the work carried out at BNGSL. In particular a discussion is presented on the pragmatic aspects of the approach and its application as part of an overall initiative or as a one-off approach to address specific IM or KM related issues as they arise in an organisation.

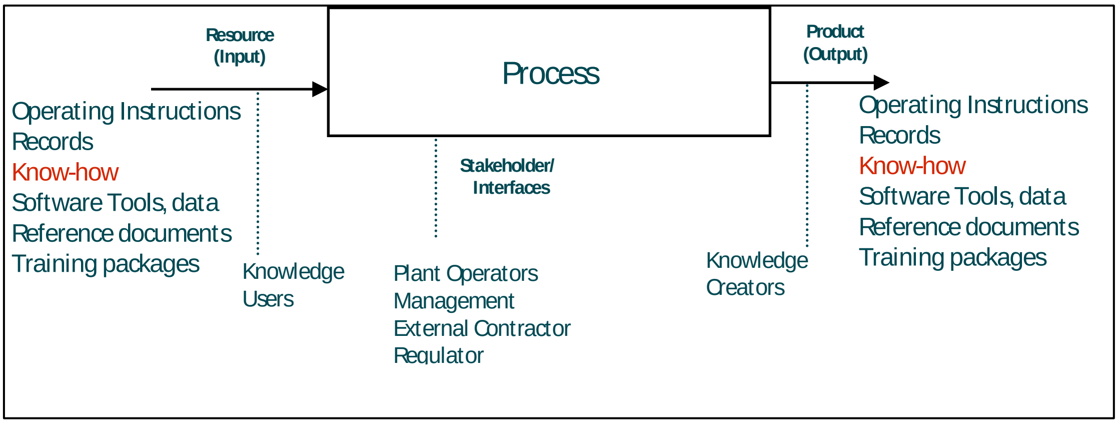

FIG 1. Knowledge Audit Model

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KNOWLEDGE MANAGEMENT IN NUCLEAR FACILITIES: THE CASE OF TANZANIA

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The applications of nuclear science and technology can be the best tool to alleviate poverty manifested through the inadequate supply of food, poor and inadequate communication infrastructure and poor health services.

In Tanzania various techniques using radiation and radioisotopes are used to improve crop production, exploration of minerals and development of water resources.

As of recent years there is rapidly increasing use of nuclear technology applications in various sector of economy.

Recently the country also experienced a long period of draught leading to inadequate supply of water to the major dams. This led the country to the shortage of electric power supply. Nuclear energy was assumed to be the permanent solution to the country's future energy demands.

The increase in the number of nuclear facilities and the country's need to have the permanent solution on the power problems, the nuclear knowledge management is an important tool to address the challenges faced the by the development of the industry and regulatory authorities as well. Initiatives have to be taken to manage and preserve the nuclear knowledge by improving the education and training of nuclear workers and the efforts to attract the younger generation.

The government through Tanzania Atomic Energy Commission (TAEC) has set strategies to manage and preserve the nuclear knowledge for the current and future generation. Measures for the aggregation and sharing of knowledge has been initiated and incorporated to the TAEC's functions stated on the Atomic Energy Act No. 7 of 2003. The functions of TAEC have put in order to enhance the effectiveness and sustainable transfer of nuclear knowledge and safe utilization as well as preservation of nuclear science and technology. To achieve the stated functions, TAEC in collaboration with IAEA, the government and other stakeholders is building the training capability to meet its vision statement of becoming a centre of excellence for nuclear security, radiation safety, radiation protection and radioactive waste management and for promotion of peaceful utilization of atomic energy for socio economic development, and also one of the mission statement of formulating and coordinating or facilitating the implementation of a national framework and infrastructure for an efficient, effectiveness and accelerated transfer, and utilization of nuclear technology and atomic energy for socio-economic development.

Also the establishment of ICT centres and INIS centre is another achievement acquired by TAEC and the country in general to sustain and build up experience, expertise, knowledge base and capacity needed to support existing and expanded use of nuclear technology and also to facilitate and coordinate the exchange of nuclear information and dissemination of the available nuclear literatures.

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IMPLEMENTATION OF TACIT KNOWLEDGE PRESERVATION AND TRANSFER METHODS

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1. Background and Definitions

The loss of knowledge does not only threaten the safe and economic operation of nuclear power plants, but has also negative effects on the socio-political system of a country. Transparent external communication is of paramount importance for gaining trust and thus a positive perception on the part of the public. 80% of the most important knowledge is unconscious and only 20% can be found in memos or books. The nuclear industry now has realized that ageing workforce represents an issue with safety and economic relevance. Knowledge preservation and transfer are therefore required to be considered within knowledge management (KM). The stakeholders who may profit from systematic KM are operators, industry, research institutes and universities, authorities, international organizations and the public. Besides, KM in terms of evaluation of research results not only improves innovation, but also the process of decision making.

2. Strategy and theory for model development

When important knowledge is detected, it should be documented thus allowing its transfer, especially if the predecessor is not available any more. The various methods for preserving and transferring it differ in the possibility of doing so and dependent on the characteristics of knowledge. Before explaining them in detail, a closer look will be thrown at the knowledge cycle illustrating the various knowledge elements and at the knowledge characteristics (see figure 1).

All knowledge elements deal with explicit, implicit and tacit knowledge.

Explicit knowledge implies declared knowledge, i.e. knowledge being conscious to the knowledge bearer. That is why it is not a problem for the employee to tell about rules and obviously learned facts. Very often, this knowledge is already written down in books, journals or memos. This is not possible for implicit and tacit knowledge. Besides, the preservation of explicit knowledge can be performed independently from its transfer.

In contrast to this relatively accessible information *implicit knowledge* is difficult to reveal, but it is still possible to write it down. Usually the knowledge bearer cannot recall this knowledge by himself, because the information is too obvious to him.

The third type of knowledge, the *tacit knowledge*, is the most difficult for transfer. Tacit knowledge contains knowledge about topics such as how to ride a bike or how to talk.

3. Application of the model

KM should be integrated in the daily work processes and better in a wholesome quality management system.

Strategic KM has to be defined by the management, since they want their ideas to have realized by operative KM. When introducing a concept for KM it has to be taken into account that all employees should be supported in that they can perform their task successfully. In order to become experts within their own working area, they need explicit, implicit and tacit knowledge not just being developed by knowing the data and signs from a check-list. Nevertheless it has to be admitted that the latter are required to gain the expertise.

Operative KM works just the other way round e.g. increasing the value of „raw data“ by adding information about its own production and location. If this information in a second step is enriched with expert experience and creativity, background data and information context, then we obtain knowledge.

Methods, operations, tools and techniques for implementing the elements of the knowledge cycle should be developed dependent on the knowledge characteristics, the applying persons (so do operators need other knowledge than structural engineers) and dependent on the overall goal. A knowledge matrix of all organisational units is helpful to identify the most crucial knowledge areas and to prioritize them. The inclusion of nuclear KM in an integrated quality management system is strongly recommended.

The speciality of nuclear knowledge is that it is both, complex and long-term. Furthermore it covers various disciplines and requires international cooperation in order to allow its efficient management. Since knowledge transfer (KT) is an important part of KM and not only the plants are ageing, but also the workforce, it is of paramount importance to link it with personnel development!

This publication limits its scope to knowledge preservation and KT. Together with an improvement of access to knowledge in general knowledge preservation and KT have proven to guarantee the most return on invest within KM.

4. Methods for knowledge preservation and transfer

For knowledge preservation and KT with respect to a collective readership or audience there are several possibilities in principle being different from knowledge preservation and KT for individuals.

4.1 Mentor program and observation

A mentor program may enhance the availability of the leaving employees' important know-how much more than written reports. Usually the predecessor shows the new employee the ropes for some time, for example for a period of three months. They are working in parallel, so that the successor gets an insight in the working method, benefiting from the advantage of asking questions right away when problems are arising.

Observation is useful if direct "learning by doing" is impossible due to intolerable risks. It allows transferring tacit knowledge as well, even though less than may be transferred by the mentor program. It is especially helpful together with discussion forums such as communities of practice or electronic "meeting rooms".

4.2 Thematic seminar gathering the tacit knowledge of experts

A possible approach of collating experienced based thematic knowledge is the organization of a seminar thus preserving at least some of the know-how of retiring experts. One may create some sort of topically condensed report containing at least the most important items and "rules of thumb". Thus the younger generation/new-comers are helped better grasp the essence of available knowledge (where should I look first? Who is it worth to ask and which persons are reluctant?). Such a procedure will not replace but rather complement already existing fundamental documents on the subject matter.

4.3 Virtual reality

Implicit and tacit knowledge contribute up to a level of 80 % to the success of an organization. Improving their codification increases its dynamics and competitiveness significantly. Thus, it goes without saying that solutions have to be found to profit most from it. Tacit knowledge is non-quantifiable and often very subtle in nature since it is based on first-hand life experiences and shaped by beliefs and social forces.

Real-life stories, case studies and use of simulation from role-playing may significantly contribute to this process and enhance an employee's "deep smarts" and thereby re-creating tacit knowledge. Virtual Reality (VR) games permit learners to fail and thereby learn without repercussions. It helps grave knowledge in the human brain through its individual reproduction on the conscious and unconscious level. In this way it allows an efficient training of the capabilities necessary to perform specified tasks, i.e. perform the right *thing* at the right *time* at the right *location*. This is done in an automated process without explicitly reflecting the actual situation.

4.4 Half-Standardized Interview

The interview, especially a half standardized interview allows capturing explicit and implicit knowledge and to some extent even tacit knowledge – when being conducted by trained interviewers. These interviews are meant to elicit the interviewees' knowledge and experience as well as their personal perceptions relating to the work processes and to the organization. An important aim is knowledge transfer to the successor and improvement potential for the organization. However, for a successful application of the interview technique in combination with a written experience report still some important problems still have to be discussed.

5. Conclusion

Many KM-Initiatives failed because there were no specified methods for conserving tacit knowledge. In contrast to information as such, knowledge is dynamic and continuously changing. When planning for the future this fact should be considered. The implementation of KM requires an exact definition of its elements together with its characteristic so, that they are consistent among the users. The knowledge elements for individuals should conform to each other and integrate explicit, implicit and tacit knowledge.

Good tools and appropriate IT-infrastructure are important, but the best way for efficient identification, transfer and development of knowledge will always remain the human being.

NUCLEAR KNOWLEDGE PORTAL: INFORMATION MANAGEMENT MAKING POSSIBLE THE KNOWLEDGE MANAGEMENT

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The world new economy is based on knowledge, its global and foster intangible things like: "ideas", information and relationship. An increasing number of organizations, recently, noticed how much is important to "know what they know" and be able to take the maximum advantage of their knowledge assets and keep them in a safe way, to be able to retrieve them in the future. According to Stewart (1998) and Sveiby (1998), the knowledge organizations are those that have structures focused on the knowledge and not on capital; those where intangible assets are much more valuable than their tangible assets; with highly skilled professionals that has a high schooling degree. The Knowledge Management (KM) is a methodology that came up from the organizations needs to organize and manage their strategic knowledge and ensure that they wouldn't be lost with collaborators leave.

The KM encloses a set of tools and methods that are the core of a new communication and information society that provides solutions that relay either on the organization as in technology. Among the organization these knowledge lays on different locations, like: knowledge bases, data bases, files, portals, etc, being distributed through all the organization. The ability to manage, distribute and create knowledge with efficiency is basic to drive the organization into an advantageous position among its competence area.

Davenport e Prusak (1999) say that the knowledge derives from the information on the same way that the information derives from data, once more it becomes clear that the relation between information and knowledge cannot be put apart. This relation resides on the assumption that the first is the path and the asset to the second. On the same way, the knowledge creation theory, of Nonaka and Takeuchi (1997), in which the knowledge is created from the interaction between the tacit and the explicit (information), the information facilitates and allows the knowledge construction.

On this context, the information portal is essential tools to implement a Knowledge Management philosophy in a company. With the use of portals, an organization can change information, from the many different sources, into useful information to create knowledge. Thus, among many advantages, we have an increased easy for people publish and access the information that they need in an optimized way.

In connection with this we have the nuclear area subject that day by day requires an increased effort of it community to spread their research, projects and information to the society. On this context, the Centro de Informações Nucleares (CIN), of Comissão Nacional de Energia Nuclear, developed the Portal of the Nuclear Knowledge (link: http://portalnuclear.cnen.gov.br), already released. Its goal is to have a single channel of access to the public technical-scientific libraries information related to the nuclear area, on a broad scope, and make it available through WEB for free access.

The Portal of the Nuclear Knowledge was built in a dynamic way, constituted by links, and is a pioneer project in Brazil. It encloses a large collection of matters related to the nuclear area that are daily updated by librarians and specialists. The Portal gathers in the same repository, information form a wide variety of sources and levels of difficult, and make it available either to specialists as well as to the general public, acting as an interface to these users. Some highlights of the Portal of the Nuclear Knowledge are:

Focal Points – a thematic view on the sites linked on the Portal, related to selected areas and of wide interest inside the nuclear science & technology: Safeguards, Licensing, Radioactive Waste, among others.

News via RSS – the Portal collects news from import sites of nuclear area, that uses the RSS technology, for an agile spread of the news, introduced on other home-pages. This resource enables the access the news of the nuclear area to the Portal users with a visit to a single site.

Bibliography – monthly a relevant theme to the nuclear area is selected and many papers, related to it, are made available.

Yellow Pages – a Catalog of services and product suppliers to the nuclear area, operating on the national and international market.

Another important focus of the Portal is the sites that offer information services, for the nuclear area, among them are the services of CIN and IAEA.

In order to keep the contents updated and adequate to the users needs, the Portal maintenance takes places with the users support through a direct communication channel, where changes, adds and deletion suggestions of themes and links are made.

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KNOWLEDGE MANAGEMENT IN A NUCLEAR RESEARCH CENTRE

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Indira Gandhi Centre for Atomic Research is an R&D Organization under the Department of Atomic Energy, India, with a mandate "To conduct a broad based multi disciplinary programme of Scientific Research and Advanced Engineering development directed towards the establishment of technology of sodium cooled Fast Breeder Reactors and its associated fuel cycles". The Centre has been operating a Fast Breeder Test Reactor with a unique Pu-U carbide fuel for more than 20 years and a Kamini Reactor based on U^{233} fuel. To fulfil the mandate, the Centre has developed over the years a strong and world class R&D base in the areas of material development and characterization, non destructive inspection and evaluation, fuel and material chemistry studies, reactor engineering and development with advanced computer aided design, analysis and 3D modelling followed by detailed experimental studies for validation, sodium technology, safety instrumentation, safety engineering studies and analysis etc. The Pu-U carbide fuel of 100,000 MWd/t burn up from Fast Breeder Test Reactor has been successfully reprocessed using innovative indigenous technologies. All these developments have enabled creation of various innovations and rich knowledge base that have led to indigenous design of 500 MWe Prototype Fast Breeder Reactor and an Integrated Fast Reactor Fuel cycle Facility. Also, the knowledge gained at the Centre is disseminated to the other strategic areas of importance to the nation.

The paper gives a few examples of how the knowledge acquired in the Fast Breeder Test Reactor has been successfully used and disseminated resulting in non recurrence of any of the incidents (that occurred earlier) in the successful operation of 20 years. The innovative ideas and experiments in the metallurgy and material developments, non destructive testing and inspection technology are highlighted to communicate examples of achieving breakthroughs based on knowledge management and innovative environment. The knowledge flow from extensive design and computer analysis backed up by experimental validation for the Prototype Fast Breeder Reactor are explained. The paper also covers knowledge management in sodium technology, an area of high relevance to sodium cooled fast reactors. The various dimensions of Knowledge Management like people, process, technology and content and the R&D required for successful application of Knowledge Management are described in the paper.

The new millennium has ushered in a new era of economy and development which is being referred as "Knowledge Economy", in which knowledge is described as the critical competitive asset of any organization. In this era, it is possession and application of valuable knowledge that supports long term superior organizational performance. It is well argued and accepted that for R&D Organizations involved in emerging and challenging technologies, knowledge is key asset.

To us in the Centre with a vision to achieve world class leadership in the fields of fast reactor technology and associated fuel cycles, knowledge management is a capability of an organization to create new knowledge, disseminate it throughout the organization and associated collaborative research and academic institutes, industries etc. Infact considerable knowledge is getting created and disseminated through collaborative programmes with these institutes.

Like any highly technological endeavour, the use of nuclear technology relies on the innovative creation, storage and dissemination of knowledge. Also the nuclear energy sector is characterized by long time scales and technological excellence. Development of innovative technologies for nuclear power and its associated fuel cycles is essential for addressing the concerns of the public at large and to make significant contribution to world energy in the immediate future.

Many nuclear experts with rich design, operation and maintenance experience are retiring from service taking with them valuable expertise. All this necessitates a good knowledge management policy to capture, store and disseminate the knowledge to the right people, at the right time.

This paper illustrates a few success stories as well as the inadequacies in knowledge management to emphasize the need of R&D and innovation in knowledge management.

The Centre has framed and adopted a Knowledge Management Policy that nurtures creation, capture, storage and dissemination of knowledge with the complete participation of the employees. Towards this, a web based Information Management Server has been commissioned with a search facility. This collates the distributed information management servers of various groups (disciplines). These servers contain the explicit knowledge generated in the Centre in the form of Design Reports, Internal Reports, Publications, Drawings etc. These servers are enriched with scientific information on a continuing basis. Appropriate security mechanisms are built in to provide the information on need to know basis and access to confidential information.

The tacit knowledge is being captured from the retiring employees through exit reports, interviews, audio and video presentations. The tacit knowledge of the serving employees is converted to explicit knowledge through periodic seminars, lectures and internal reports. The way we do not know which branch bears fruit in a tree, in an organization, from which level the innovation comes from is not known. Hence in our Centre, the quality circles are nurtured which many a time come out with innovative ideas based on practical knowledge base. All this information is ported to the Information Management Servers. Proper framework is devised for the employees to come forward and realize the paradigm shift that “Knowledge is Power” to “Knowledge sharing is Power”.

This policy is enabling innovation & development. Knowledge management is also used for nurturing innovation especially among the young personnel of the department. We believe that the knowledge management and innovation quotients are interwoven & interrelated.

INNOVATION AND NUCLEAR KNOWLEDGE: FROM THE PRESERVATION OF KNOWLEDGE TO THE DEVELOPMENT OF KNOW-HOW

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The renaissance of the nuclear option for sustainable energy supply has created the basis for innovation on nuclear systems, reopening the range of technologies to be considered in the future.

The Generation IV International Forum, and the International Project on Innovative reactors and Fuel Cycle (INPRO) are certainly the most active initiatives since 2000 to specify objectives for future nuclear energy systems, to establish a comprehensive methodology and users requirements, and to select technologies that are most likely to meet nuclear energy needs beyond 2030 and to be developed in international collaboration. The stringent criteria assigned to future nuclear systems foster the achievement of breakthroughs in technologies.

Innovations for future nuclear energy systems call for a good knowledge of the past achievements and current practice. At the same time, innovations are often to be sought at the boarder between different areas, which explains the different nature of the knowledge to be gathered, and the different processes to achieve this goal.

Among the technologies that experience a renewed interest today, HTR, SFR and MSR have been developed to the stage of experimental and/or prototype reactors. Before being phased out, they have been the subject of investigations for decades and a considerable amount of data is available from the past experience. Initiatives to develop data bases on those types of reactors, on a national basis or an international basis, turn out to be invaluable resources for the development of 4^{th} generation nuclear systems as they permit to accelerate the development of new technologies today, while saving decades of R&D and significant expenses.

For the SFR, an exemplary and precursory approach in France has permitted to preserve the knowledge gained during five decades of R&D and to be passed down to future generation despite the governmental decision to decommission Superphenix in 1998 (MADONA encyclopaedia, Phenix lifetime extension project, continuous operation of the sodium school).

The HTR-10 and HTTR experimental reactors under operation in China and Japan, respectively, perpetuate R&D activities on HTR technologies. The creation of the European Network on HTR Technologies (HTR-TN) in 1998, involving 18 organisations, is intended to share the experience acquired in this field by member countries of the European Union.

For the MSR, the considerable amount of results accumulated by ORNL in the 60’s and 70’s forms a significant basis for the demonstration of the viability of a MSR breeder concept. The MOST project, supported by Euratom, gave the opportunity to revisit the potential of MSR and to update the data and knowledge on MSR.

Those examples show that initiatives are now taken at the international level. Today, the international dimension has become crucial, which explains the essential role of IAEA and OECD/NEA to compile open background information. At the same time, sharing the knowledge acquired within the framework of national programmes, such as envisaged in the

Generation IV International Forum for ultimate commercial uses, calls for a fair treatment of the intellectual property rights.

In addition, knowledge in nuclear engineering and design calls for maintaining education and training in nuclear fields, while making the access easy to international participants, especially those from countries having decided to phase out of nuclear.

Initiatives have already been taken by the European Commission to implement a network of Institutes offering training in nuclear science and engineering, so as to establish a European program of education in nuclear engineering. Other initiatives are considered on specific subjects such as an international sodium school, which would build on existing sodium schools in France and in Japan.

New technologies for the management of information offer opportunities to preserve for the future not only documents but also technical data, computer codes, calculation results and algorithms.

Large international initiatives such as the Generation IV Forum and INPRO certainly contribute to the objective of the development of know-how by stimulating multi-disciplinary interaction and also providing foundations for the development of education and training.

FUSION: CROSSING THE DESERT BETWEEN BASIC RESEARCH TO ITER

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Le 21st November 2006 seven partners (UE, Japan, China, India, RF, South Korea, USA) signed in Paris the documents of the treaty creating the ITER organisation. The treaty is expected is now being ratified by the concerned parliaments. This will constitute the last step of a very long process conducted under the auspices of the IAEA and developed in 3 phases: ITER conceptual design, engineering design, negotiations for organisation and site construction arrangements. ITER is a large research facility for the demonstration of fusion at a level of 500MW. Its construction is planned to take 10 years and will be followed by a 20 year operation phase. It constitutes a worldwide collaboration of unprecedented size.

Over the last decades the fusion research programme went through drastically different phases: well supported in the eighties, it obtained good success with the first fusion power produced by JET; it then went down to an all time low in 2000 when the European Commission considered terminating the programme altogether.

This talk will examine the key elements for first crossing the desert and then for the resurrection with a very ambitious programme. No doubt that the galloping cost of petrol and the setting-up of a meaningful project are dominant features. However, one should not overlook other key factors: consensus building of the scientific community focussing on key issues, close cooperation with the academic world which ensures the progress and the transfer of knowledge, collaboration with industry to keep alive the technical knowledge, public information notably at school level and last but not least active international collaborations under the auspices of IAEA and IEA to make the best use of facilities and human resources in the tough conditions of diminishing budgets.

It is hoped that this limited experience of fusion to ’knowledge management in nuclear facilities’ might be useful to other fields.

THE CHALLENGE OF KNOWLEDGE MANAGEMENT IN A NEWLY – FORMED NATIONAL LABORATORY

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Introduction

In the autumn of 2006, the UK government made a commitment to establish a National Nuclear Laboratory based around Nexia Solutions and its 'state of the art' facility at Sellafield in Cumbria. The initial phase of the work to establish the laboratory is now complete and it has a remit for the following roles:

- to play a key role in supporting the UK's strategic R&D requirements
- to operate world-class facilities
- to ensure key skills are safeguarded and enhanced
- to play a key role in the development of the UK's R&D supply base."

It is evident that to be successful the National Nuclear Laboratory will need a strong capability in knowledge management to underpin its activities. Our origins in the R&D communities of BNFL and UKAEA have given us a broad portfolio of capabilities which range from reactor technology through fuel cycle technology to waste management and the knowledge held by our people is one of our major strengths. However, the capabilities and knowledge do need to be maintained and developed, for which we have a four part strategy:

- Strengthen internal systems & processes
- Undertake strategic R&D programmes
- Build networks with the nuclear industry across the world
- Build links and partnerships with academic institutions

Systems & Processes

Internal systems and processes need to be strengthened to make the capture and sharing of knowledge and information more efficient. A key element will be succession planning for more experienced technologists.

R&D programmes

Work is proceeding to develop a robust portfolio of R&D programmes. As well as fulfilling our remit to play a key role in the UK's strategic R&D requirements, this will also ensure that skills maintenance goes beyond formal training. Involvement in R&D programmes will develop capabilities in our younger scientists and engineers, particularly, to generate solutions relevant to the industrial-scale application of nuclear technology. We aim to use our R&D programmes to facilitate skills transfer from experienced practitioners across a wide range of disciplines.

Industry Networks

Building networks across the nuclear industry needs to complement the R&D portfolio. We recognise that a creative approach is needed, and one example is that Nexia Solutions has created roles called Senior Fellows. Senior Fellows are leading technologists who are expected to "act as ambassadors". That is to say that they will develop links between technologists inside the laboratory with those in academia or other industries. In this context, knowledge management is to work with the 'tacit' knowledge held by experts in a variety of organisations. Establishing the correct links ensures the knowledge is more complete than it would otherwise be and enables it to be focused more effectively on real issues.

Each senior fellow role is based around a fundamental technical discipline which provides the theme for the development of technical links. Currently we have roles in the following areas:-

- Materials behaviour
- Corrosion
- Actinide chemistry
- Criticality
- Reactor Systems

Senior Fellows are nationally and internationally known and respected in their field and are expected to maintain their specialist support role within Nexia Solutions in addition to interacting extensively with key research organisations, academia and relevant other industries.

Academic links

The National Nuclear Laboratory will aim to maximise the value of its work for the UK and therefore must find ways of increasing the synergies between its own capabilities and those in universities. One example of how the National Laboratory may work is Nexia Solutions' existing initiative called University Research Alliances (URA). The knowledge management aspect is similar to that for industrial networks, ie. dealing with 'tacit' knowledge. Academic and industrial knowledge can complement each other if the right links are established. Equally, important is the role that universities can play in renewing the knowledge base, through formal education programmes and training in research through MSc and PhD projects.

University Research Alliances are an initiative to help replenish the UK's academic base in nuclear technology. Four URAs have been established:

Radiochemistry	– at the University of Manchester
Particle Technology	- at the University of Leeds
Waste Immobilisation	- at the University of Sheffield
Materials Performance	- at the University of Manchester

Also in the university context, the senior fellow role is helping the national laboratory to develop a concept of 'seamless' teams, in which university departments are able to contribute to a given R&D project in a more direct and powerful way than the traditional ways of working.

In summary, the UK national nuclear laboratory is adopting a four-part strategy towards knowledge management. It aims to build from its current strong base and to use a number of innovative approaches.

KNOWLEDGE MANAGEMENT AND ATTITUDE TOWARDS NUCLEAR ENERGY: THE RUSSIAN DIMENSION

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The paper presented by the author at the first IAEA Knowledge Management Conference (2004, Saclay, France) was dedicated to the main achievements of the Soviet Union and Russia in generation and systematization of nuclear knowledge and in providing human resources for their application.

Nevertheless, some well-known nuclear professionals consider the breach of the normal knowledge transfer process, which occurred when nuclear power plants have been transferred from the half-military nuclear complex with its high level of discipline to the civil "boiler power industry" (quite unprepared for that), as one of the relevant causes of the Chernobyl accident.

The crises of 1980-90ies (Chernobyl accident, changed political system, collapse of the USSR) have stopped the development of nuclear power industry and gave a severe blow to the nuclear knowledge management system.

In present conditions, which can be surely described in the terms of "nuclear renaissance", it seems important to trace, how the preserved and developing knowledge management system is influenced by the attitude towards nuclear energy in the country and in its "components" (governmental authorities, energy community, public), as well as to follow up the role of nuclear professionals in forming the above attitude.

Governmental support of the nuclear education, which has begun from its establishment in the Soviet Union almost simultaneously with the start of the "Uranium Project", was preserved, and continues at present. This Conference will undoubtedly analyze in detail the issue of nuclear education.

Less known, but vitally important, is the government's "target" support of talented young scientists (and their tutors), who, in conditions of obvious destructive processes in the Russian science of the 90-ies, continued to support, and then to develop the potential of nuclear research and development. The government conducts and expands its support programs for young Russian scientists, leading scientific schools (President's grants), and unique facilities of Russia, which attract young scientists by the possibility to work together with nuclear science leaders and on world-level facilities. The share of the "nuclear sector" in the total amount of support of technical sciences reaches 20%.

The list of measures of direct governmental support aimed at preserving knowledge (for example, financing of this activity-related technologies, scientific schools for young scientists, etc.) can certainly be continued, including, for instance, such a dramatic solution, as the postponement of military service (in conditions of the military duty law), granted to thousands of young nuclear specialists in the last years (however, this year is the last for this privilege).

However, political and moral support of nuclear energy on the governmental level is equally important. This support, especially in Russian conditions, has a strong influence on the social climate and, thus, on the inflow of specialists, which determines the very possibility of nuclear development. Statistical data shows that, after the President announced the development of nuclear energy to be one of the most important tasks of the country and the program of major budgetary investments in this national economy sector was adopted, the share of positive nuclear-related publications in the central mass media increased more than thrice (from 20% to over 60).

Perception of their proper place in the **country's energy sector,** along with the development of corporate contacts with their colleagues, was a weak point of nuclear professionals for a comparatively long time. This is unacceptable in current conditions, when, besides synergetic projects (nuclear energy for production and transportation of fossil fuels, etc.), which virtual yet, there exists – and is already understood in the fossil energy sector (also not without using the authoritative resource) – the need and possibility for Russia to quit its "gas addiction" and to invest its export income in developing nuclear energy and saving fossil fuels, instead of burning them in power plants. Creation of a pro-nuclear climate in the traditional energy sector would directly promote the inflow of specialists, while also preserving and developing the nuclear specialty in the energy education system.

Preparation of documents for G8 Summit in St. Petersburg (2006) – where the nuclear professionals made a weighty contribution, especially as concerns the issues of long-term energy strategy – is a good example of the above.

The **public** attitude towards nuclear energy determines the status and perspectives of the critical nuclear development factor – that is, involvement and training of new specialists, which must have enough time for receiving the experience of the community of the "first nuclear era" specialists, which is rapidly thinning out.

It should be clearly understood that the initial nuclear energy image existing in the "public memory" for 60 years of existence does not allow this industry to become one of traditional and customary technologies of the energy mix, which the public would estimate on the basis of its objective parameters. The Russian dimension in the attitude towards nuclear energy is peculiar, because the majority of the country's population considers its social position as unsatisfactory – and this circumstance, as sociologists know well, enhances the external impact on the public opinion and leads to its radicalization and to mythologization of actual problems.

Today, in conditions of nuclear energy propaganda launched on the government level, nuclear professionals should shift the center of their attention from the already-proven "existence theorem" to calm and positive dialogue with the public on regional and local issues, which are regularly and professionally enough raised by environmentalists.

On the whole, nuclear professionals, anxious about inevitable and fast development of their sector and, in the first turn, about assuring personnel for it and transferring their knowledge to the new generation, should learn not only to solve their internal problems in an efficient way, but also to interact with the outside society. This need was already understood, and the IAEA played an important role in this connection (we know that there is no prophet in its own country).

Leaving aside the whole spectrum of activities of the Federal Atomic Energy Agency and the nuclear community in the field of nuclear knowledge management improvement (which makes the subject of other presentations), let us only note the critical importance of the current moment, when the reform of the nuclear industry complex and the establishment of a vertical holding company (a sort of nuclear Gazprom) enters its practical phase. The new law adopted with this view doesn't forget the nuclear education, too, so there are reasons for hope that this process would bring new prospects to knowledge management.

In these activities, nuclear professionals should not miss a single opportunity to send a "positive message" to the public. For example, such an informational occasion, as the 60th anniversary of the first Soviet (and the world's oldest operating) reactor was successfully made a nationwide mass media event and a convincing demonstration of the Russian science and engineering potential.

The issue of knowledge management and specialists' involvement and training is not a narrowly-corporate issue, and requires from nuclear professionals skillful interaction with the general public and separately taken social groups. Russia has an interesting experience in this field, and we are ready for efficient international cooperation.

NUCLEAR KNOWLEDGE MANAGEMENT OVERVIEW AT ICN

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This paper provides a general view of management knowledge put into practice within nuclear facilities. Institute for Nuclear Research (ICN) has implemented an Integrated Quality Management System for Environment, Labour Health and Safety [1], intended to facilitate:

Global planning of the system by establishing actions, responsibilities, terms and resources required for the accomplishment of the objectives.

Allotment of resources needed to maintain and upgrade the Management System, correlated with technological and economical options of the Institute.

Assessment of the global efficiency of the Institute.

The concept of Management Knowledge related to the activities within the lifetime of nuclear facilities is substantiated by four levels, which include:

- Research – development;
- Control of production and service supply: Operation of nuclear facilities;
- Decommissioning of nuclear facilities;
- Issues related to environment, labour safety and health.

The first knowledge level consists of know-how implementation by means of research and development. For instance, following the national research program for the Management of Radwaste and spent fuel in conditions of nuclear safety, new technologies can be implemented as well as the conception and implementation of new nuclear facilities. Ensuring the specific requirements regarding environment protection and labour health and safety is also a must.

The second level is “technical knowledge”, identified by procedures, standards and all technical specifications which ensure safe operation of nuclear facilities and of classical support facilities that contribute to the fulfilment of safety functions. For example the operation of nuclear facilities is an essential process of the Integrated Management System, being described in the procedure EO-AC-07 “Operation of Nuclear Facilities”.

The third level of management knowledge related to nuclear objectives and installations is intended to elaborate a program of evaluation and implementation of the decommissioning activities which should comply with national legislation and standards.

The structural knowledge related to decommissioning regard the accomplishment of three major objectives:

- Strategic Framework;
- Planning Process;
- Dismantling Process.

The management decisions with respect to these objectives shall be taken on the basis of common knowledge acquired and discussed during workshops. They shall be taken in consensus.

The fourth knowledge level, focused on quality, environment, safety and labour health, contributes to the insurance of operation of nuclear facilities in safety conditions and, consequently, to the issue and maintaining of authorizations for the quality management system applied to the activities within the facilities lifetime performed at the Institute.

This model of knowledge is very important, since the way of understanding a Knowledge Management System is base on all four levels. The knowledge does not represent a simple accumulation of data; it can be transferred in the basis of processes related to KM such as lectures, procedures, standards and documents. At the same time, the stored KM may serve as technical support in the organization of Cernavoda NPP operation.

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THE IAEA INTERNATIONAL DATABASE ON IRRADIATED NUCLEAR GRAPHITE PROPERTIES: A SUCCESS STORY FOR BOTH NEW BUILD AND LIFE EXTENSION OF COMMERCIAL POWER PLANTS

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Graphite has enjoyed extensive use as a nuclear moderator (and *de facto* construction material) since the late 1940s. In commercial plant it has seen the greatest use in gas-cooled reactors of the Magnox and AGR types (UK designs) and the French UNGG reactors. It has also been employed in water-tube reactors such as RBMKs.

These reactor types may be thought of as ‘Generations I and II’, and many (Magnox, UNGG) are approaching the end of their commercial operating lives or are already in decommissioning. However, thoughts have turned in a number of countries to the ‘Generation III’ high-temperature helium-cooled reactor, employing graphite as a reflector and as part of the fuel matrix, either in the form of prismatic replaceable structures (current Japanese prototype HTTR and US Peach Bottom and Fort St. Vrain and early European experimental ‘Dragon’ reactor) or in the form of spherical fuel elements (former German design for AVR and THTR, used in Chinese HTR-10 prototype and the basis of South Africa’s PBMR design). ‘Generation IV’, which may include Very High Temperature Plant containing graphite structures, is now also under active consideration.

Concern was expressed in the mid 1990’s by the authors that the huge body of expertise and the knowledge base on the irradiation behaviour of graphite could be lost to the future designers through both loss of experienced personnel with time and the generally poor quality of record keeping which characterised the mid-to-late twentieth century industry. Graphite undergoes complex changes in its physical, mechanical and chemical properties under irradiation which need to be fully understood in terms of the microstructure of particular graphite formulations and types in order to best specify future materials for the more arduous environments. The issue remains important too for existing reactors where the fluences experienced by the graphite in commercial plant are now moving ahead of databases created using materials testing reactors with high fluxes. These problems were discussed at an IAEA consultancy held in the UK in 1995 [1], and it was agreed to approach the Agency with a proposal on how this archiving of knowledge might be achieved.

This took the form of a presentation to the International Working Group on Gas-Cooled Reactor Technology by one of us (AJW), and led to a number of subsequent discussion meetings at which the basis of the Database structure was worked out, and the Database was formally constituted under the authority of the Agency in 2000 with the United Kingdom, the United States of America, The Netherlands, Japan and Germany (through Forschungszentrum Jülich directly) as founding Member States. These have been joined subsequently by Lithuania (associate member) and Korea, The Republic of.

The nature of the Database structure has recently been radically changed, but it was initially created as a Microsoft ACCESS system using password-protected files, since some data-donating organisations were sensitive to the more open distribution of data which was considered proprietary either for design or for ongoing safety-case reasons. However, the development of newer graphites, based on this experience, for future plant, and the ageing of existing plant, has allowed most contributing organisations to downgrade the classification of their material. All members of the Database subscribe to a 'Working Arrangement' and then have free access to almost all data in the system. However, the importance of data security for nuclear safeguards considerations is always kept under scrutiny.

Each of the Member States of the Database with a significant operating history of graphite-moderated reactors has donated extensive amounts of data either through its national nuclear organisations or through commercial reactor operators and, after extensive debate, the majority of users favoured a reversion to simple Microsoft EXCEL spreadsheet formatting for ease of use by the graphite specialists. However, the creation of a fully relational database is not ruled out for the future.

The technical steering committee for the project is currently working to a four-year plan, half completed, to amass the remaining bulk of data from existing plants and historical experiments. Recently, twenty-first-century standards of Quality Assurance have been applied to the data input process [2], with a separate evaluation of the technical status of each input data source, although it has to be recognised that modern QA standards cannot be applied retrospectively to old sources of data which are often in the form of faded, typed notebooks and reports.

The completion of the 'four-year plan' does not imply that the steering committee will end its work. There is scope for much useful analysis of the data, as well as consideration of other forms of graphite information useful to the decommissioning engineers, which might in the future form a separate arm of the activity.

Acknowledgement: Initial funding, and by far the largest ongoing financial support for the project has come from the United Kingdom Health and Safety Executive's Nuclear Safety Directorate, concerned with supporting the continued safe operation of older plant in the UK, whilst additional funding on an annual basis has been secured from database sponsors – the Toyo Tanso Co. Ltd of Japan, The PBMR (Pty) Ltd of South Africa, SGL Carbon Ltd (Germany), and Graftech International Inc (USA).

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KNOWLEDGE MANAGEMENT IN NUCLEAR R&D INSTITUTES

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Nuclear Knowledge Management is increasingly becoming important as a tool to provide technology transfer to a younger nuclear work force, provide a solid foundation for power and non-power nuclear applications and advance the next generation of nuclear technology. For the advancement of nuclear science and technology, KM needs to be implemented in R&D organizations. Application of KM techniques should lead to an efficient management of their R&D activities. This paper describes the benefits that can be attained by the adoption of NKM techniques in nuclear research institutes.

The key strategic goal of a nuclear R&D organization is creation of new knowledge with respect to its deployment into products and services. In the context of R&D, KM is defined as an integrated process to capture R&D knowledge hidden in various knowledge based activities and resources, transform it into usable knowledge and diffuse it throughout the R&D organization for future use. According to Malhotra, KM ensures that right knowledge is applied at the right place and time and it is about doing the right thing instead of doing things right [1]. Its application to R&D will avoid unnecessary duplication of research. It can help support both individual and organizational learning from past successes and failures while guiding future actions and changes.

For R&D to succeed knowledge should be collected from all sources both internal and external to an institute. This is a necessary condition for any R&D activity which requires its personnel to continuously enrich their knowledge and use it to develop new information and knowledge. KM can help collect knowledge from multiple areas and integrate it with relevant knowledge from internal and external sources. The process involved can be divided into four steps, knowledge acquisition, knowledge organization, knowledge dissemination and knowledge application. KM focuses on processes or methods to find, create, capture and share knowledge and on technology to store and make knowledge accessible. R&D organizations need to invest in acquiring relevant knowledge and people engaged in research should be able to make use of a variety of knowledge sources which will enhance their ability to innovate.

Research has shown that sharing of knowledge is essential for creating an innovative mindset. Many people are afraid that by sharing knowledge they will lose their importance. A major component of the implementation of KM is to change this culture and encourage knowledge sharing rather than hoarding. In order to promote the flow of tacit knowledge there should be an access to peoples information. Ambrecht et al [2] have proposed that a R&D organization should build a supportive culture enabling knowledge flow, promote creativity, capture knowledge of experts and accelerate R&D process. KM should address organizational level issues such as creating new or revising old processes to generate knowledge, developing incentives to promote knowledge sharing. It should utilize both formal organizational memory (such as databases, repositories and networks) and informal organizational memory (like culture and personal relationships) to store knowledge. Sharing knowledge through communities of practice consisting of individuals with similar skills and responsibilities can be effective. KM can help connect people who will otherwise not be able to meet.

Like all high technology areas, nuclear science and technology depends upon acquired knowledge and accumulated expertise – scientific research reports, data maintenance records etc. Data preservation is a scientific and professional obligation and absolutely necessary in any R&D institute. The collection and storage of all information relating to a research project should be carried out during the development stage and proper quality assurance ensured. All observations and results relating to a project should be complete, written systematically and in detail. Failures should also be recorded. Development and documentation should be a team effort.

Succession planning is particularly important in nuclear institutes. Highly qualified and motivated professionals have brought the nuclear industry where it is today. A large number of these people have either retired or are retiring taking with them a substantial amount of knowledge and institutional memory. These people are also aware of previous failures and trials (not properly recorded) which is of value for future development. To overcome this problem and preserve the knowledge, sufficient number of well qualified personnel should be available. Conducting training of newly recruited people and continuing education of existing people by these about to retire people is a must.

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RESEARCH NETWORK INVOLVING RETIRED EXPERTS AS A MEANS TO KEEP ALIVE RELEVANT KNOWLEDGE – THE CASE OF IPEN IN BRAZIL

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On one hand, by appraising the drivers that influence energy policies worldwide, one come to the conclusion that the prospects for a revival nuclear power deployment have never been so clearly designed. On the other hand, looking to what has been the situation over the last twenty years, it is evident that, should the revival come to strength in the next five to ten years, one will run into knowledge shortage problems of many kinds. This feeling, which is the tip of an iceberg, has been constantly alerted by almost everyone studying the scenario and these concerns, thanks to the proactive and catalytic role of the IAEA, gave rise to the growing field of nuclear knowledge management - NKM.

Despite the repeated recommendations of IAEA, the Brazilian nuclear area as a whole is not making coordinated efforts in this concern. Reasons are many, but probably the root cause resides in the fact that the country does not have a nuclear program or a clear policy concerning the role of nuclear in the Brazilian electricity generation matrix. There are, however, some isolated initiatives in some institutions concerning mapping, diagnostic and preservation of critical nuclear knowledge.

This work has studied a social network - SN that has emerged naturally and that is helping to transfer and keep alive the knowledge of retired experts at IPEN. Enabling and driving factors that have strongly contributed to the network formation and its sustainability can be summarized as:

- The fact that Human resources of IPEN belong to a special career of science and technology for which to have master and doctor degrees represent significant salary increases.
- The location of IPEN, sited in the campus of the country's leading university, São Paulo University – USP and the special institutional arrangement under which it functions as the nuclear technology unit of this university. Researchers of IPEN, with doctor degree and teaching abilities, can become also professors of graduate courses within the USP grid.
- The fact that the Brazilian Council for Scientific and Technological Development - CNPq has a range of research productivity fellowships for people who achieve a certain sustained level of publications. Depending on the researcher's classification, this mechanism includes a monthly income addition plus small funds for expenditures in traveling and laboratory consumables.

Items a and b have caused many IPEN employees start to work towards graduate education at USP (IPEN). As they take most of the disciplines in subjects related to nuclear, which are taught by senior researchers / professors of IPEN, they end up performing their degree research work in fields that, most of the times, are related to the current work of their advisors at IPEN. Retired researchers usually keep the professor status and activities, probably because of their strong research group links, constructed over the years, but also because to have students is possibly the most important lever to keep up the indexes to maintain the CNPq productivity fellowship.

This dynamic network is a powerful natural mechanism to transfer knowledge from retiring experts and also to disseminate nuclear knowledge, since IPEN has a diversified portfolio of disciplines that is also of interest to other students of the USP community.

Based on the co-authorship of publications involving people from IPEN, collected annually from 2000 up to 2005, the social network evidenced by these data bases was analyzed. For the network "photography" of each year a set of indicators were computed:

- a participation index of retirees in the publications of IPEN (# of publications involving retirees / total # of publications);
- a partnership index measuring the "social capillarity" of the average collaborating retiree (# of current workers that co-authored / # of retired co-authors);
- a publication productivity index for the retired researchers; and
- some SN indexes, such as, diameter of the network, relative nodal degree, density, centrality and so on.

Based on the SN indexes and their time evolution, the key players, the strengths and weaknesses of the network were identified and analyzed and some very interesting conclusions were drawn. By analyzing the causes that explain performance variation between the most and the least prominent actors it was possible to better understand the behavior of the network. The leading actors were also studied with respect to its activity before and after retirement to better understand the knowledge transfer.

A set of conclusions and suggestions are presented on how this mechanism could be further enhanced and utilized. Furthermore complementary interaction networks, based on questionnaires and interviews with the leading actors (hubs), will be mapped and if possible their partial results will also be added to this work.

KNOWLEDGE MANAGEMENT IN NUCLEAR FACILITIES

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In the beginning of the XXI century the nuclear energy aroused a new interest around the world.

Russia, China, USA, and other countries announced their ambitious plans of its development. The main difference of present moment investigations from those when nuclear opposition was rather strong is the deficit of resources, both financial and intellectual. This deficit forms the needs in nuclear knowledge conservation and transfer.

As well known, the decision of this task may be reached through the creation of a national system for nuclear-technology knowledge management [1, 2,].

The item of knowledge is a new term, introduced for determination of notion defining a more indivisible unit in practice knowledge turnover. The unit must allow its unique identification while storing in external memory or further searching. In common, it is assumed that the knowledge item is a set of structure blocks, denoting some “essence” of message clear for a user without additional context. For example, it may be some text denoting a full thought, picture (scheme) together with explanation details (legend, subscripts, names, etc.). It is obvious, that it can not be a separate word, because it has a different sense in a different context. It can not be a bare function line because it needs some additional description of axis, dimensions, etc.

The nuclear-technology knowledge item has a complex structure because it can not be self-identified in storage media as a word, set of words or number. For its identification it is necessary to assign some additional attributes. These additional characteristics are meta-properties and do not contain the essences of knowledge item. These meta-data are used in searching, description or comparison. Meta-data are more important for a knowledge engineer than the item. Very often the item may not be stored as itself. It has only own representation as meta-data.

Of course, attributes identifying the item in a context must reflect functional relations between the context and the essence of the item.

Methodologically, the task may be solved by creation of a special taxonomy of notions, which belongs to the application domain under investigation. Selection of needed notions from words of a language being used for knowledge description is a difficult task, and requires attracting high-level specialists. Fortunately, in the nuclear technology area the taxonomy is largely made. In 2006, the IAEA INIS and Nuclear Management Section specialists together with workgroups from member states introduced a multilingual thesaurus [3]. However, the actual thesaurus is only a hierarchy of terms (words) but not a hierarchy of essences. Thus, it is necessary to add the thesaurus with interpretation of each term. It is an immense and complex work for specialists of the INIS member states.

The new concept of nuclear power in Russia is named “a new technological platform” (NTP). The nuclear technology knowledge management activity for nuclear power may be determined through base actual needs of new generation of specialists. The top-priority aim of this activity is a previously created knowledge inventory and their formalization.

Formalization may be made by timely created sets of meta-descriptions such as “maps of nuclear knowledge” and ‘maps of needs in nuclear knowledge”. Intersection of these sets will give a list of priority works for preservation of knowledge for NTP.

Obviously, qualified data sets on physical and nuclear properties of substances will be required first of all. Most of them are stored in data centers of Rosatom, for example in Nuclear Data Center in Obninsk.

The meta-description of the qualified data are indexed by terms of INIS thesaurus and described as it is recommended by IUPAC ThermoXML standard [4] and MatXML [5].

Simultaneously we try to create our own XML-standard for description of complex heterogeneous data required for NTP (NucXML).

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A THEORETICAL APPROACH AND PROBLEM DEFINITION TO KNOWLEDGE MANAGEMENT IN THE FIELD OF ADVANCED NUCLEAR REACTOR DEVELOPMENT

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Development of the fast breeder reactor (FBR) in Japan was started in 1970, being conducted for more than 35 years so far. The experimental reactor of FBR, Joyo, reached its initial criticality in 1977 and the prototype reactor, Monju, in 1994. Development of the next larger FBR is now being performed, whose operation is expected to start about 30 years after the initial criticality of Monju. The expected duration of the development for the larger reactor is too long to keep the related people such as designers and engineers in the developmental field, leading to the change of generation over the working lifetime, though such the problem was less severe in case of the development of Monju, whose initial criticality was 17 years later than that of Joyo.

The development of FBR is required to take long time beyond the working lifetime of researchers, designers, technicians and engineers, who have gained high expertise including know-how through the related engineering and technical experience. To continue the development of FBR and fulfil the developmental goal successfully, a new systematic base is currently required to manage the expertise gained by experts over the change of generation.

On the other hand, knowledge was paid attention and considered as an important asset as well as capital funds in business companies since 1990s, leading to the so-called knowledge management conducted mainly in the business field. Information became also important previously and the progress of the information technologies is significant since 1980s. Nowadays the knowledge management seems to be related to the information technologies.

To plan a new systematic base to manage the expertise in the FBR development field, the experience of the knowledge management conducted previously in the business field should be taken into account. However, management necessary to handle the expertise accumulated in brains of experts over the change of generation would not be the case of the knowledge management in the business field. A long term strategy is required for the knowledge management in the nuclear developmental field.

Furthermore, a wide range of understanding of knowledge itself leads to a wide range of knowledge management activities in the business field. Understanding of knowledge itself as well as information seems to be different in detail between people related to the knowledge management in the business field and specialists related to the academic field such as information science or knowledge science.

From these viewpoints, to program the knowledge management adequately in the FBR development field, consideration should be made at first about what knowledge is as well as information and then about how to manage the knowledge.

In this paper, preliminary definitions of data, information and knowledge are presented due to a model of cognitive understanding in a human brain on the basis of cognitive psychology, brain science and philosophical ontology [1]. Consideration is also made on the characteristics of development in technology that differ from discovery in science [2]. Due to the definitions and consideration, basic discussions are made on a meaning of the management of explicit knowledge as well as tacit knowledge, and subsequently on effects expected from those management activities. Finally, discussions are also made on current problems that should be solved and directions of solutions to plan the knowledge management in the FBR development field characterized by the long duration beyond the change of generation.

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STANDARDIZED ANALYSIS OF RESEARCH AREAS AND KEY CONCEPTS OF NUCLEAR SCIENCE AND TECHNOLOGY AT CUBAENERGIA

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A computer program for performing standardized analysis of research areas and key concepts of nuclear science and technology is under development at the Cuban INIS National Center, Cubaenergia. The main components of the system are shown in Fig.1.

INIS Webspirs		CAIMAN
Search/Download (on line)		Analysis (off line)
INIS Database ⇳ Intranet Web Server ⇩ INIS Record Files.txt	Storage ⇨	INIS Record Files.txt ⇩ Unitary Thematic Analysis ⇩ Relational Thematic Analysis

FIG. 1. System for thematic content analysis of INIS Database record files.
CAIMAN, (Content Aimed Massive Analysis).

The components on the left represent the web application developed and provided by the IAEA INIS Section. This system is installed on the Cuban INIS Server at Cubaenergia. The INIS Bibliographic Database, representing the state-of-the-art documented nuclear knowledge worldwide, is taken as the standardized information source for the analytic work [1]. The components on the right represent the computer program for information retrieval and analytic processing.

At present the work is aimed at the characterization of the thematic content of large collections of INIS records. The key element for this kind of analysis is the descriptor field. Each term of the Indexer-Assigned Descriptor field, (DEI), is considered as an observable irreducible thematic content entity. The INIS Thesaurus is taken as defining the analytical terminological frame of reference of about 20100 dimensions [2]. The vector space model of the term-by-document matrix is used to represent the INIS record files [3, 4]. Computing methods of linear algebra and projective geometry are applied for information analytical processing and visualization.

Unitary Thematic Analysis module performs the basic content analysis for each INIS record file as a separate unit. The complete projection of an INIS record file gives the set of INIS Thesaurus terms spanning its thematic content. The number of spanning terms measures the thematic content.

Relational Thematic Analysis module performs the term-term projection pair wise across the collection of INIS record files providing the measure of the thematic content common for each pair of INIS record files. The thematic content relational matrix and its projective eigendirections for visualization purposes are thus calculated.

TABLE I. DEMONSTRATIVE STUDIES NUCLEAR POWER AND NUCLEAR TECHNIQUES

Nuclear Power				Nuclear Techniques			
Areas		Records	Terms	Areas		Records	Terms
1	non-proliferation-policy	1551	1144	1	agriculture	4043	3410
2	nuclear disarmament	952	812	2	hydrology	7511	3645
3	nuclear-power	6775	3292	3	medicine	2328	3324
4	power-reactors	4716	3830	4	nuclear-medicine	13217	5244
5	safeguards	6073	3176	5	radiation-protection	43199	8691
6	safety	22708	7262	6	radurization	1667	1690
7	security	3346	2446	7	sustainable development	1026	1328

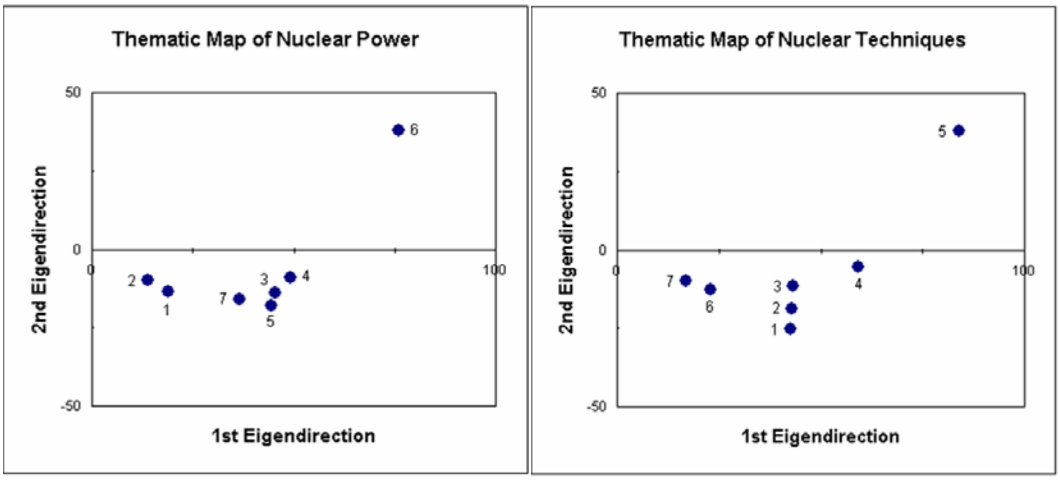

FIG. 2. Thematic maps of Nuclear Power and Nuclear Techniques.
(See TABLE 1 for point number explanation)

The research areas and results of the demonstrative studies Nuclear Power and Nuclear Techniques are depicted in Table I and Fig. 2. The research areas are characterized by two measures, records and terms. The number of records is used for bibliometric research. The number of spanning terms accounting for the thematic content gives a quantitative insight into the documented nuclear knowledge. Both studies covered totally the records contained in INIS Database from 1970 to the latest available July 2006. About 119000 bibliographic records contained in 14 INIS plain text record files, 25.9 megabytes, were analyzed.

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KNOWLEDGE TRANSFER OF RADIATION PROCESSING TECHNOLOGY IN MALAYSIA

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Malaysia has been participating in various technical cooperation programs at international, regional and bilateral levels with the primary objective of transferring technology from developed countries to support national socio-economic development. Various mechanisms of technology transfer were pursued in Malaysia via technical cooperation programs with sponsoring agencies such as the IAEA, JICA and FAO, to achieve this objective. These collaborative partnerships serve as a mechanism to transfer technology and knowledge. However, technology transfer does not take place without knowledge transfer as knowledge is the essential and crucial process of technology transfer.

A study was conducted to investigate aspects of knowledge transfer based on the experience of the Malaysian Nuclear Agency in the national development of the radiation processing technology through the technical cooperation programs of the IAEA and JICA. The mechanisms of technology transfer involved under the technical cooperation programme were reviewed. Interviews with key and relevant personnel, and survey through questionnaires were carried out to track the mechanisms of transfer, to identify the knowledge transferred and the conditions conducive for transfer from both sides of the relationship. The research also identified the various kinds of synergic effect as a result of the knowledge transfer realised by the technical cooperation programmes between the multilateral and bilateral cooperation.

This paper reports the study carried out and factors influencing knowledge transfer of radiation processing technology in Malaysia through the technical cooperation programs of the IAEA and JICA. Recommendations and lessons learned to promote more effective and efficient cooperation as a mechanism for knowledge transfer in the future are also reported.

KAZAKHSTAN NUCLEAR INNOVATION PROJECTS AND PROBLEMS OF EDUCATION AND PERSONNEL TRAINING

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At present in the Republic of Kazakhstan there are four large innovation projects [1] related with application of an advanced nuclear technologies: “Creation of Kazakhstan Materials Testing Tokamak” [2]; “Implementation of Inter-Disciplinary Research Complex on the Base Heavy Ions Accelerator at the L.N. Gumilev Eurasian National University (ENU)” [3]; “Creation of Technology Park in Kurchatov city” [4]; The Implementation of the Center of Nuclear Medicine and Biophysics”. Items of personnel training in these projects – together with special ones – are playing the principal role.

The first project is directed on supporting of Kazakhstan participation in the ITER project, and on development up-to-date trends of science, techniques and technologies, as well as on training of high-qualified scientific and engineering personnel for this domain. In particular the theoretical and methodical model for training of professional and competent specialists for operation at a thermonuclear synthesis facility is developed at the al-Farabi Kazakh National University. Here in the framework of Summer University (SU) ‘Specialists for Tokamak’ the special curriculum for thermonuclear facilities operational personnel training is implemented [5]. Activity of the SU is focused on the – preparation and organization of selection competition of talented young people for participation in the SU. The competition is conducting between leading universities students (having master or bachelor degree). Content of the SU theoretical course is adapted to real demands of Kazakhstan nuclear organizations. The first training sessions were conducting in 2005.

One of principal task for creation of Inter-Disciplinary Research Complex at the ENU is training of high-qualified specialists of natural-science and technical profile for the Kazakhstan economy. The core facility of the complex is DC-60 heavy ion accelerator. The commissioning of the accelerator gives an opportunity to create experimental training base for scientists, postgraduates, students.

Purposes for implementation of Technology Park in the Kurchatov city are:

- Development of modern infrastructure for manufacturing application of new technologies;
- Provision of high-tech developments promotion ahead to a market;
- Solution of existing socio-economic problems of the Kurchatov city.

Key facilities of the Technology Park: reactor complex; industrial accelerator; gamma-radiation facility; production and laboratory facilities. On the base of the techno park facilities the Center for training and retraining of specialist for nuclear energy and industry of Kazakhstan is planning.

Necessity of implementation in the Republic of Kazakhstan of the Center of Nuclear Medicine and Biophysics is conditioned by a serious country developmental lagging in nuclear medicine methods application. Operation of the Center is closely related with main existing facilities of the Institute of Nuclear Physics of the National Nuclear Center (INP NNC) – research reactor WWR-K and isochronous cyclotron – and new objects (building of radio-pharmaceutical products preparation, treatment-and-diagnostic building; biophysical laboratory; building of radiation sterilization). PET technology for the first time in Kazakhstan will be applied in the Center. In the process of the project launch a number education and training measures is planning. Training of the engineering personnel is conducting at the INP NNC special course. Also for accelerator facilities specialists a fellowships at a lotron producing company is organizing. Chemical engineers and analysts will study at the Institute of Biophysics (Moscow, Russian Federation) on experimental tests of and quality control for radiopharmaceuticals. Doctors, radio diagnostics specialists will study at the corresponding medicine centers. Doctors on radionuclide diagnostics, computer tomography, magnetic resonance tomography and radiology will study abroad in the specialized centers.

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SYNERGY BETWEEN NUCLEAR RESEARCH, INNOVATION AND EDUCATION: THE EURATOM APPROACH TO NKM AND APPLICATION IN COMMUNITY RTD FRAMEWORK PROGRAMMES

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In this keynote paper, the following questions are addressed:

1) What are the innovation challenges in energy technologies, in particular, in nuclear fission, that the European industry and research organisations are faced with ?

in the short (today), medium (2015) and long term (2040) ?

2) What kind of response do the EURATOM research, development, demonstration and deployment (RDDD) programmes offer as solution to the above challenges ?

and what has been achieved so far, using the Community instruments ?

In the general debate about innovation in energy technologies in the EU-27, there are two types of challenges:

scientific and technological (S/T) *challenges* related to *research* and technological *development:* the main instrument provided by the EU is the research Framework Programme (FP)

economic and political (E/P) *challenges* related to engineering *demonstration* and industrial *deployment*: the main instruments provided by the EU are economic and regulatory incentives.

To facilitate the industrial *deployment* of modern energy infrastructures in Europe, the stakeholders (in particular, the systems suppliers and the energy providers) are looking for their national governments, together with the EU, to play a triple role:

initiator of ambitious *research and development* programmes: e.g. to orient public funding to visionary research programmes (basic and applied) on well targeted issues with potential breakthroughs and to cosponsor large infrastructures of common interest to be shared for research and training

financial investor: e.g. to support and facilitate investments for *demonstration and deployment*, especially during the transition period between two technological steps (in particular, when going from the current traditional economy to the future "*clean, clever and competitive*" economy)

regulator to ensure that the *citizens' interests* are defended and that the *industrial competition* is fair (level playing field at international level): e.g. establish a common European framework for the mutual recognition of best practices for safety culture, risk governance, codes and standards.

The synergy between nuclear research, innovation and education, and the related RDDD actions are also discussed in the *Strategic Energy Technology Plan* (SET plan), that the Commission will draft by the end of the year, as a follow-up action on the Green Paper "*An Energy Policy for Europe*" (EPE) issued in January 2007. Nuclear energy will naturally be part of the SET-Plan. The general aim is to provide an objective perspective on the different energy technologies which will or might become available between now and 2050 to tackle the "energy supply issue" while respecting the environment (CO_2 and GHG free) and being competitive. The prospects for market penetration of a series of low carbon technologies will be analysed, be it for electricity/heat conversion or for transport technology. As a result one would have a better picture what are the real chances of the different technologies and what is needed to support their development.

The history of nuclear fission power production is usually divided in four technological Generations (called I, II, III and IV), with timescales extending from 1950 to around 2040. This paper focuses on the S/T challenges of the future Generations III and IV, and on the type of solution they may offer to meet the objectives of the new *Energy Policy for Europe*:

Generation III (2015): competitiveness (a.o. increased plant performances, 60 years lifetime), and enhanced security and safety (a.o. "practical elimination" of severe accidents)

Generation IV (2040): enhanced sustainability (a.o. full actinide recycling) and enhanced competitiveness (a.o. cogeneration of heat and power for process heat, synthetic fuels and hydrogen).

Besides examples of innovation in nuclear fission and of relevant Euratom actions, this paper shows:

- to what extent are all components of the Euratom RDDD integrated in one coherent approach ? that is: the setting up of a EU framework for the production, integration and dissemination, and exploitation of knowledge and technologies related to nuclear fission
- to what extent do the results of Euratom RDDD in nuclear fission innovation respond to the 4 technology goals proposed for Generation IV and for partitioning & transmutation ? that is: *(1) sustainability, (2) economics, (3) safety,* and *(4) proliferation resistance*.

Finally, the role of the stakeholders in the success of international nuclear RDDD programmes is recalled, i.e.:

the research organisations (public and private)

the systems suppliers (e.g. nuclear vendors, engineering companies, etc)

the energy providers (e.g. electric utilities, heat and/or hydrogen vendors, etc)

the regulatory bodies and associated technical safety organisations (TSO)

the education and training institutions, and, in particular, the universities

the international framework (e.g. IAEA and OECD/NEA) and the civil society.

ENEN ASSOCIATION AND ITS ROLE IN STRENGTHENING NUCLEAR EDUCATION AND TRAINING

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European Nuclear Education Network (ENEN) Association was established in 2003 as a non-profit-making association pursuing the preservation and the further development of higher nuclear education and expertise. There are effective and associated members. The effective members are academic institutions and research centres providing high-level scientific education in nuclear field. The associated members have a firmly established tradition of relation with members in the field of nuclear education, research, and training. They commit themselves to support the ENEN Association.

The main objectives of ENEN Association comprise the following activities:

- to deliver a European Master of Science degree in nuclear engineering,
- to encourage PhD studies,
- to promote exchange of students and teachers participating in the network,
- to establish a framework for mutual recognition,
- to foster and strengthen relations between universities, nuclear research laboratories, industries, and regulatory bodies,
- to ensure the quality of academic nuclear engineering education training and research,
- to create incentives and increase career attractiveness for the enrolment of students and young academics in nuclear disciplines.

The ENEN Association was established as a result of the fifth European Framework Programme (FP) project entitled European Nuclear Education Network. To demonstrate the feasibility of European nuclear engineering educational schemes, several educational coursed were established. The courses on Nuclear Thermal Hydraulics and Nuclear Reactor Theory, organised within the Belgian post-graduate programme on nuclear engineering, are organized in a highly modular way and taught in English to facilitate and enhance participation of European students. The Eugene Wigner Course for Reactor Physics Experiments is another example of international networking. It is a three-week course with a high involvement of practical exercises organized by four European universities for master and postgraduate students from European as well as non-European countries.

The educational networking activities which have started within the 5FP were further deepened and also extended towards training of professionals in the scope of the 6FP project NEPTUNO (Nuclear European Platform for Training and University Organisations). This project has brought together all aspects of European education and training in nuclear engineering, nuclear safety, and other nuclear disciplines. It main objectives were to ensure that the courses in nuclear education offered by European universities are high quality and compatible with the Bologna declaration and to harmonise professional training and accreditation schemes in the sector. Along with educational course mentioned above which were continuing also within this project, several training courses were also introduced. The

Training Course on Nuclear Safety and/or Nuclear Safety for Subcontractors can be cited as examples of training courses with international participation. The project has delivered an operational network of institutions for academic education in nuclear studies at the master, doctoral and post-doctoral level that is complemented with research organisations, regulatory bodies, and industrial partners supporting research and development, bench-training and continuing professional learning schemes.

Based upon a mutual recognition as well as an intensive exchange of views between the ENEN partners, consisting of a representative cross-section of nuclear academic institutions and research laboratories of the EU-27, a coherent and practicable concept for a European Master of Science in Nuclear Engineering (EMSNE) has emerged. This concept is compatible with the Bologna philosophy of higher education for academic engineers in Europe. The students register in one ENEN-accredited institution and acquire the required credits in ENEN-institutions of their choice. After obtaining the formal degree of Master of Science in Nuclear Engineering from their home institution, the ENEN, on behalf of its members, grants the quality label European Master of Science in Nuclear Engineering. The first series of EMSNE certificates has been awarded to three students (two from France, one from Romania) in a ceremony on December 12, 2005.

Finally, the expertise of the ENEN Association in harmonization of European education and training schemes in the field of nuclear engineering has lead to an application for another 6FP project entitled “Consolidation of European Nuclear Education, Training and Knowledge Management” under the acronym ENEN-II. The project was approved and runs under the co-ordination of the ENEN Association since October 2006. This Coordination Action consolidates and expands the achievements of the ENEN and the NEPTUNO projects attained by the ENEN Association in respectively the 5th and 6th framework programme. The ENEN-II project is aiming at developing ENEN Association in a sustainable way in the areas of nuclear engineering, radioprotection and radwaste management, including underground disposal. Nuclear education and training networks will be developed at the national level to provide a solid basis for networking at the European dimension.

Supported by the 5th and 6th Framework Programme of the European Community, the ENEN Association established the delivery of the European Master of Science in Nuclear Engineering certificate. In particular, education and training courses have been developed and offered to materialise the core curricula and optional fields of study in a European exchange structure. Pilot editions of those courses and try-outs of training programmes have been successfully organised with a satisfying interest, attendance and performance by the students and the support of nuclear industries and international organisations. The involvement of ENEN in the 6th EC Framework project EUROTRANS will further enlarge its field of activities into a realm of nuclear disciplines. The ENEN Association further contributes to the management of nuclear knowledge within the European Union as well as on a world-wide level, through contacts with its sister Network ANENT in Asia, and by its participation to activities of the World Nuclear University.

FUTURE PERSPECTIVES OF HUMAN RESOURCES IN NUCLEAR TECHNOLOGY – THE KOREAN CASE

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Synopsis. The prospects for growth for the nuclear power industry in the Republic of Korea, have improved notably in last few years, as the need for generating capacity grows to meet burgeoning energy demand and developmental needs, and as environment, climate change and energy supply security continue become matters of rising concern. Nuclear technology itself has also changed, with evolutionary and innovative changes in reactor design and safety measures.

Nuclear technology development both requires and fosters human resource development (HRD). A continuous, consistent and well-managed programme of HRD is crucial to assure continuity over time in the needed capacities, skills and knowledge, and to establish and maintain a cadre of manpower variously trained in different nuclear-related skills and educated in nuclear relevant fields. It also fosters the development of spin-off industries and synergies. Productive and goal-oriented HRD&M is a dynamic long-term process that balances the dynamics of supply and demand of human resources with respect to the education, recruitment, maintenance and proper training of the human resources needed for industry operations as well as innovation.

Such a programme in fact was the foundation for the birth of the Korean nuclear industry, with the government sponsoring nuclear-related- training and education for hundreds of persons under the tutelage of companies and countries overseas having experience with nuclear and related sciences and technology. This cadre, once repatriated, formed the nucleus for domestic training and education programmes as an integral part of nuclear energy development and consistent with national policies. HRD&M in Korea today comprises an educational network among academic and research institutes, government and industry.

Forming such a cadre is not the result of a one-off training process, but must be planned and sustained consistently over time and its talents regularly applied. Experience shows that training without continued application and without long term commitment of a coordinated core of participants and programmes, is virtually worthless. HRD management must be a dynamic process that includes not only basic education and specific training but also looks to other spin-off learning/industries and to basic inputs/learning as part of the process.

Comprehensive HRD&M policy and strategies for nuclear energy is one of the essential and priority issues for long-term nuclear energy development. Since a nuclear power programme cannot exist in a vacuum, future HRD&M schemes for nuclear energy should include a broad base of disciplines, sciences and technologies, perhaps within a framework of national sustainable development goals, generally considered to include economics, environment and social concerns. Within this context, areas of interest would include technical performance, nuclear science and engineering, as well as matters related to the economic performance of new nuclear generating capacities compared to alternatives (standards, economics, finance, liability, risks, internalization of externalities), environmental protection (emissions, wastes, decommissioning), social and political issues, energy demand and supply, intergenerational concerns about long-lived wastes and resource depletion, supply security considerations, and innovation.

The medium and long term nuclear human resources projections to be developed here for the Republic of Korea up to 2030 are not predictions but rather scenarios of plausible ranges of future nuclear human resource requirements based on nuclear power generation projections reflecting a variety of economic, social and environmental driving factors. Both the LOW and HIGH projections are derived from Input-Output analysis based on a review of national nuclear technology development programmes and plans.

SHAPING TALENT FOR SUSTAINABLE BUSINESS DEVELOPMENT – NUCLEAR TRAINING PRACTICES

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The AREVA group, which is committed to offering its customers technological solutions for reliable CO_2-free power generation, is both a designer and vendor of nuclear units and operator of nuclear facilities. The group's ambitions are to maintain its knowledge capabilities and develop skills at the level necessary to respond to its business objectives around the world.

The AREVA Human Resources department has developed an action plan to support business strategy which aims to accelerate its investment in people, to reinforce recruitment and retain high quality talents and valuable skills and knowledge.

Today, there is a global challenge for attracting the best talent and becoming an employer of choice. The group must be creative in attracting, retaining, mobilising, engaging, developing and rewarding its people.

AREVA has 61 100 employees worldwide, of which 38 000 work in nuclear activities. In 2006, some 10% of the nuclear workforce represented newcomers, and the group anticipates recruiting a similar significant ratio in 2007. The group has to be ready to tackle a surge in recruitment which is believed will continue over the next 5 years.

AREVA has developed, on an international level, networks and partnerships with academic institutions. New programs are being created and promoted to prepare for the integration of future skills needed in the nuclear business. The group has coordinated and pooled resources to gain efficiencies and to strengthen its presence on the employment market.

Plans are in place for employee integration and development, mobility, and managing the transfer of knowledge and specific skills. In this context, internal professional training paths are being developed and reinforced, including geology of uranium, dismantling, reactors, nuclear safety and the environment.

AREVA is developing a common methodology to lever the transfer of knowledge through training modules, sharing experience and mentoring. Mentoring programs have been deployed for over ten years in several countries, and the group intends to implement a mentoring process on a global scale. Each of the group's entities offer specialised training programs tailored to their own activities covering a wide range of professions.

The AREVA group makes it very clear that maintaining operations for its nuclear industrial facilities at a level of excellence, is possibly a daily challenge, and definitely a must! Attracting people with valuable skills and maintaining knowledge are crucial to group strategy.

The AREVA Human Resources Department's mission is focused on the following:

- Professionalizing managers in order to capitalize on skills. The first step was to update the mapping of core skills and focus on prioritizing needs.
- Sharing experience, increasing networking and reinforcing communities in different areas.

- Conducting prospective long term studies on the best methodologies and tools to accompany innovation throughout the group.
- Supporting the Expert policy via a process at group level and a dedicated AREVA Corporate University training module.
- Promoting group training courses on energy and nuclear disciplines.

Promoting the group's nuclear activities in the public sector is extremely important in order to attract newcomers from increasingly diversified origins, in the perspective of more international and diversified projects.

With this in mind, the top management of AREVA openly expressed the decision to position sustainable development as a keystone of group strategy.

The AREVA Human resources network is committed to shaping talent and playing a strategic role in contributing to the group's sustainable business development.

THE CAPABILITY CONUNDRUM

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AMEC Nuclear recognises that a skilled workforce is essential to the success of its business. In the current global climate, the potential for new build in the UK, new build underway in Europe and across the world and the acceleration of Clean Up programmes, the competition for skilled staff is fierce. So how do companies develop and grow their Capability?

What are the issues? There have been several initiatives undertaken in the UK to identify skills gaps. One example is an exercise undertaken by COGENT, the sector skills council for the Nuclear Sector, who undertook a comprehensive forward looking gap analysis for the industry in 2005 and who have now proposed a number of interventions to address the gaps identified, one of which is the creation of a Nuclear Skills Academy a second is the creation of Career Pathways.

Some of the gaps identified cover shortages of skills that we face today but, more worryingly for the future, the projected down turn in the numbers of young people studying Science and Engineering subjects, both in schools and Universities and a shortage of apprenticeship places in the UK paints a gloomy picture. Where will our future capability come from?

At AMEC Nuclear we recognise that we need to act now to protect our business and ensure we maintain, develop and grow our capability. We are working closely with COGENT to help to develop Career Pathways to encourage young people to the industry and we are delighted to have secured a place on the shadow board of the National Nuclear Skills Academy, an exciting project which will provide a focus for excellence in workforce skills development. Employers in the Nuclear industry have said that they want a Skills Academy that will provide national leadership in training provision and will move employers and employees from their current level of skills to those which will be needed to take these critical industries forward into a sustainable future in the UK.

In order for us to assess what we need for the future, the first thing we have to do is understand what we have today. Our key asset is our people, their skills and experience – their knowledge.

At AMEC Nuclear we have created a Qualifications and Experience (Q&E) register. This contains data on the qualifications, skills and experience of all of our staff. As well as allowing us to demonstrate to our clients that we have SQEP personnel, it allows us to understand what we have, our capability. This is a vital tool to help us run our daily business, it opens up the knowledge of the organisation to everyone.

Utilising the Q&E register we have undertaken a fundamental gap analysis to understand what capability we have and to identify any gaps. We now have both short term and long term plans in place to close those gaps, through training and development, multi- skilling, knowledge transfer from our highly experienced staff to our less experienced staff and ongoing recruitment.

On order to achieve our plans we will:

- Continue to support and expand our University network, to provide staff to help to keep course material current and provide mentors and supervisors. This helps us to ensure a pipeline of Graduate Trainees into our scheme.
- Continue to support local schools to play our part in encouraging children to take up Science subjects
- Continue to support COGENT to assist in the proposed interventions and with a growing blue collar workforce we are keen to ensure that the Nuclear Skills Academy is a success.

TRANSFER OF NUCLEAR ENGINEERING KNOWLEDGE AT HANOI UNIVERSITY OF TECHNOLOGY: LESSONS LEARNED AND CHALLENGES

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Hanoi University of Technology (HUT) has been being the most important polytechnic education centre of the country for half a century. Nuclear Engineering Education Programme (NEEP) was started at HUT since the year 1970, right after establishment of Department of Nuclear Engineering at the University according to the initiative of the first Minister of Ministry of Higher Education of the country. Since the year 2000 the Department changed its education programme to adapt it to the actual circumstances in the country and renamed as Department of Nuclear Engineering and Environmental Physics (DONEEP).

The objectives of the HUT's NEEP are as follows:

1. To train up nuclear technical manpower for development of peaceful uses of atomic energy in Vietnam.
2. To prepare initial nuclear technical human resources for introduction of Nuclear Power into the country.

Aiming at these objectives, the Programme achieved remarkable results such as inestimable contributions to introducing and then developing the NDT radiography method in Vietnam, to improving and developing the atomic energy applications in the country, to providing important parts of technical human resources for strengthening the nuclear community of the country.

The duration of 37 years of implementation of the Programme may be divided by 3 periods: from 1970 to 1989, 1990-2000 and from the year 2001 up to now. During the first period, the Programme was fully supported by the leadership of the University and the Ministry of Higher Education. The second period was full of difficulties. This was the period of searching the ways for preserving and adapting the Programme to the new circumstances in the country. The present period is the one of searching the ways for developing the NEEP at HUT.

The lessons learned from 37-year implementation of the HUT's NEEP are as follows:

1. To establish proper objectives aiming to satisfy the urgent short term and/or long term demands of the country is the most important guarantee for success of the Programme.
2. To find out close relation between the courses to be studied and the above-mentioned demands of the country is a very important guarantee for success of the Programme.
3. To train up teaching staffs of high consciousness of responsibility and of a quality as high as possible is a key guarantee for success of the Programme.
4. To adapt the Programme for providing student knowledge which should be of a)- Wide enough profile (for heightening capacities of seeking jobs of graduated students in today labor market in the country), and b)- High-

enough quality (fore better integration and successful co-operation) is a necessary factor to attract students to the Programme.

5. To develop close contacts and cooperations with the related institutions in the country in order to make the Programme suitable and more attractive as well as to get a practical plan of using the young people trained-up by the Programme is another necessary factor for its success.
6. To establish and develop effective international co-operations is of extremely high importance in heightening level of teaching staffs and strengthening technical base for rapid and considerable improvement of the Programme quality.

In the present period, especially after the Vietnam Prime-Minister signed in the beginning of the year 2006 to approve the strategy for development of peaceful uses of atomic energy in the country up to the year 2020, HUT's DONEEP has to face a number of challenges on its way to contribute considerably to meeting new demands of the country. The big challenges may be listed as follows:

1. Lack of suitable NEEP;
2. Lack of sufficient knowledge on nuclear power engineering and nuclear power safety;
3. Lack of experienced educators for running the NEEP; and
4. Lack of sufficient incentive to involve and to keep people to work for the Programme.

For overcoming such serious challenges, the HUT is trying to make the following efforts:

1. Setting up a new NEEP in close co-operation with Vietnam Atomic Energy Commission and other related institutions;
2. Organizing an effective conglomeration for running the new Programme by involving related units of HUT and some other institutions;
3. Intensifying international co-operations and making them more effective;
4. Taking the possible measures in order to attract and stimulate young people to follow and to work for the Programme.

UTILIZING THE UMASS-LOWELL RESEARCH REACTOR TO ENHANCE KNOWLEDGE TRANSFER IN REACTOR OPERATIONS

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A renaissance of nuclear science and technology has begun. To meet the expected needs of the nuclear power industry and various governmental organizations (e.g. DOE and NRC), there will be an increased need to train (non-nuclear) scientists and engineers with some specialized training in the safe and effective application of various nuclear technologies. To this end UML is developing a new online Nuclear Power Fundamentals program focusing on the operation and safety of nuclear power systems.

The primary target audience is Civil, Mechanical, Electrical, and Chemical engineering students or working professionals. Engineers who take this program will be able to contribute to the nuclear workforce. The goal of the online Nuclear Power Fundamentals program is to provide a strong educational base in the fundamentals of nuclear technology and reactor safety including reactor operations. Fundamental concepts needed to understand the key aspects of nuclear technology, with a focus on the basic design and safe operation of nuclear power systems will be taught. Topics will include basic nuclear and radiation physics, nuclear reactor physics, shielding, nuclear heat transport, and nuclear power systems and safety.

The unique aspect of the proposed curriculum will be the “hands-on” live remote reactor laboratory experiences and general emphasis on experiential learning that will be integrated throughout the online program. The “hands-on” distance nuclear engineering training will offer a meaningful nuclear reactor laboratory component within the online curriculum. This laboratory capability is available via the *nuclear101.com* website and the UMass-Lowell Research Reactor (UMLRR) Online application. The UMLRR Online application will be used to provide a number of live demonstrations and laboratory experiences using the full capabilities of the UMLRR facility. These learning experiences will involve both core physics and balance-of-plant considerations. Typical physics-related experiments and demonstrations might include, for example, a normal reactor startup sequence, an approach-to-critical experiment, the generation of differential and integral blade worth curves, some basic reactor kinetics, or the effects of xenon and temperature on core operations.

Utilizing the UMass-Lowell Research Reactor will enhance knowledge transfer in nuclear engineering theory and reactor operations. The “hands-on” approach to engineering education is a proven pedagogy and will be used to provide a strong foundation in nuclear power and safety fundamentals that would not otherwise be available to a wide range of students and working engineers who will, upon completion of the program, add to the nuclear talent pool and help resolve some of the current workforce concerns within the nuclear industry.

THE ANENT WEB PORTAL AND CYBER LEARNING

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The web portal for an Asian Network for Education in Nuclear Technology (ANENT), which was developed in 2004 [1], is now in operation. Meanwhile, the web portal is being upgraded to provide additional functions as needed along with the progress of the ANENT program. The progress is oriented toward the establishment of a soft infrastructure including cyber learning. This has led to the development of a cyber platform as well as a cyber learning program.

ANENT is a network to promote education and training in nuclear technology in Asia [2] and it is striving to desseminate knowledge and information on nuclear energy to a broader audience by networking with people and utilizing information technology. Korea Atomic Energy Research Institute (KAERI) has taken a coordination role for one of the ANENT group activities, which is a web-based exchange of data and information on nuclear education and training. Accordinly, KAERI developed the ANENT webportal [3], which consists of functions for individual group activities and coordination committee activities, a centralized database on education/training organizations from ANENT member countries and their curricula related to nuclear science and technology, a system of links with websites related to nuclear education and training, and other information on ANENT, such as events, publications, etc. Now, the webportal facilitates in data and information exchanges through offering communication forums and data on 48 member organizations and their curricula, papers/materials from 2 workshops and 3 coodination committee meetings, and others.

In order to facilitate in a cyber learning progress, a cyber platform has been developed and added to the ANENT webportal. The platform is designed to be user friendly and capable of effectively dealing with conceivable cases for a learning management process within the framework of operating the ANENT activities in terms of learning related activities (academic courses, training courses, meetings, self learning), learning management types (open, approved, closed), and learning delivery types (on, off, blended). Thus the overall structure of the cyber platform consists of 14 modules as shown in Figure 1, where the involved user groups are learners, lecturers, course managers and general managers, while the concerned learning stages are a course preparation, registration, learning and post learning.

The cyber platform provides several open courses for general users and approved courses for limitted group members for testing the performance of a learning management system. Figure 2 shows an example of lecture being provided on a cyber platform. In paralell, an effort is being made for a collection and cosolidation of the available course materials from the IAEA and ANENT member countries, to make them available on the ANENT webportal. Another effort is being made to create new courses and their cyber learning contents in particular for master courses on nuclear engineering. These will be followed by the establishment of a joint operation system for cyber learning courses, and a pilot operation of some of the prepared courses before a fully operational stage.

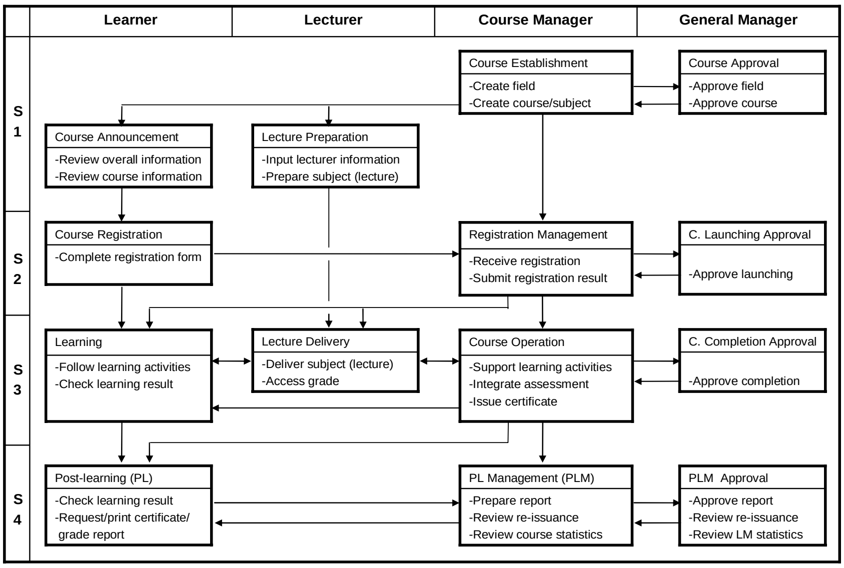

FIG. 1. The overall structure of the cyber platform developed for the ANENT webportal.

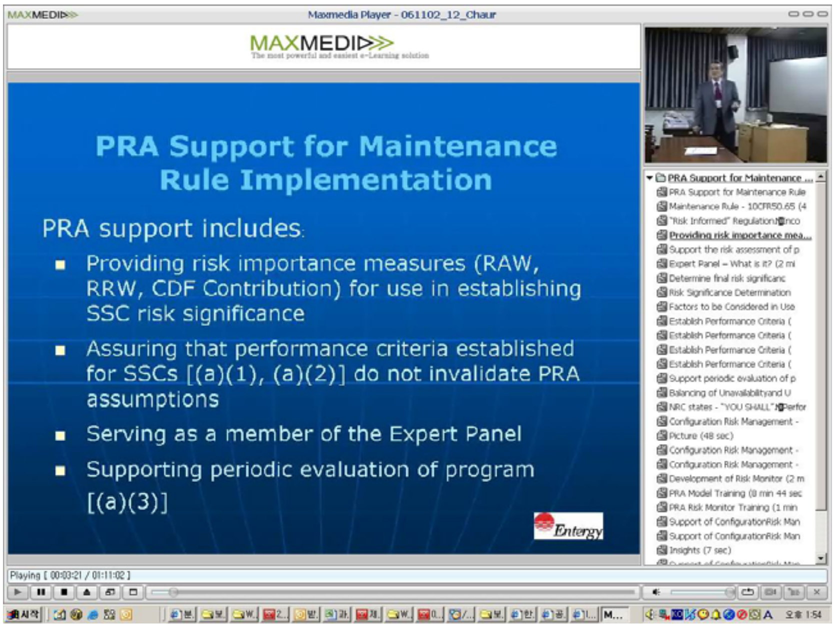

FIG. 2. An example of a lecture being provided on a cyber platform.

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NUCLEAR HUMAN RESOURCES MANAGEMENT IN SERBIA

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Over the past fifty years Serbia passed a way from a founder of the International Atomic Energy Agency and a country with an extensive nuclear program which was supported by the knowledgeable and experienced expert human sources, to the period followed by political and economic difficulties and major changes. They, among the other factors, caused a considerable modification in the scope of the nuclear program and a range of its activities which were diminished. Inherited nuclear infrastructure, as a legacy of the past, comprises nowadays significant and complex issues to be solved in a serious and urgent manner in the forthcoming period, what requires a high level of knowledge and sufficient and adequate human sources. Brain drain, aging workforce, absence of a well established nuclear education system and strategy and a lack of younger experts to which the experience could be transferred are, gradually, but certainly, leading to a loss of knowledge and capabilities to handle and cope with the existing requests and the ones of the future overall development of nuclear energy and its application in the peaceful purposes. To overcome this situation, an active approach and serious consideration of all the relating elements with a goal to define future directions and prospective in the nuclear human resource management in Serbia are therefore a task to be undertaken by the state without a delay and a prerequisite for a future development.

TRANSFER OF RADIOACTIVE WASTE DISPOSAL KNOWLEDGE TO FUTURE GENERATIONS: A STIFF CHALLENGE FOR UNIVERSITIES

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In general, effective knowledge management strategies rely on the capacity to perform a full range of allied functions, among which education and research are the key components. However, in most countries and notably in Europe, universities which have to conduct leading-edge research and to supply society with future skilled staffs on radioactive waste disposal, suffer from both the shortage of the institutional national support and the decline of interest among students.

This paper gives an overview of the academic educational challenges in geological disposal of radioactive waste. Prior to presenting possible solutions to overcome difficulties encountered in this field, the causes of the present failure that seriously threaten the future provision of human resources are identified and analysed. Some of the main findings are:

- The poor image of nuclear issues in general and the lack of public confidence in the management and disposal of radioactive waste in particular.
- The smallness of the radwaste community and the narrowness of the job market at the national level.
- The organisational structure of most universities that inhibits partnerships with non-academic institutions and impedes collaborative activities.
- The reticence of most governments to invest public funds in the academic education on radwaste disposal.

These particular motives added to the common problems shared by the whole nuclear sector such as the lack of educational programmes, the ageing of teachers, and the decline in academic R&D activities, bring about the need for collaborative actions. The paper gives an example of possible solutions through the development of a European academic initiative.

In response to the rising alarm about the future shortage of expertise, EURATOM has launched the ENEN II[7] project. The goal of this project is to consolidate the European nuclear education, training and knowledge management activities in the areas of nuclear engineering, radiation-protection and radioactive waste management including underground disposal. Studies in this last field is conducted by a consortium called PETRUS[8] group, which unites 15 leading European higher education institutions and relevant stakeholders (nuclear waste management agencies, research centres and industry). The main objective of the PETRUS group lies in creating attractive common university courses on geological disposal with a particular emphasis on multidisciplinary topics. The development of a common curriculum aims at sharing the best human resources and pedagogic materials available in each partner

[7] European Commission 6th FP project No. FP6-036414 for years 2007-2008

[8] Programme for Education, Training and Research on Underground Storage

institution, so as to incite talented students to choose and pursue studies on underground disposal. Beyond the educational objective, the group aims at federating academic efforts for the development of co-operative multidisciplinary research.

The paper describes successive steps towards these goals that are:

- The identification of needs, the inventory of available resources and the conception of the common educational programme by taking into account both academics and stakeholders point of view.
- The development of the common curriculum, which is adequate to address the identified needs
- The development of a framework for the mutual recognition and accreditation of the common curriculum,
- The settlement of a plan for assuring the update, dissemination and long-term sustainability of the common educational programme,
- The development of a framework for improving and supporting academic research activities (i.e. PhD programmes).

Live Distance Teaching using the synchronous 2-way audio and visual capability of the Internet-based systems is one of the outstanding aspects of this project. This method allows supplying live lectures to students at multiple distance sites and enables broad dissemination of the curriculum beyond the consortium partners.

The paper concludes with the expected outcomes of the present project underlining the vital requirement to win the radwaste academic educational challenge as it play a pivotal role in generating, acquiring safeguarding and transfer of knowledge.

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IMPROVEMENT OF NPP TRAINING TO ENSURE A TRANSFER OF CRITICAL KNOWLEDGE

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Maintaining nuclear competencies in the nuclear industry and nuclear regulatory authorities will be one of the most critical challenges in the near future. The adequate management of human resources, proper educational system and training approaches and methods to achieve and maintain the proper competencies of personnel are indispensable elements of knowledge management for nuclear industry. To transfer the knowledge from the experience to the newcomers, to establish the consistent links between the national educational system and qualification needs, to respond to the changes in the nuclear technology, to ensure the adequate level of corporate memory are the examples of the links between the knowledge management and the training.

The paper presents the extensive information on the challenges, the nuclear industry encounters in the training and qualification (T&Q) of the personnel, and the good practises that are in use at nuclear power plants to respond to these challenges. The information presented is based on the experience from the IAEA OSART missions which review the training and qualification matters at the nuclear power plants among the other operational management programmes. IE/JRC-EC supports the OSART activities by providing the experts for the specific operational areas and participating in the development of the IAEA Safety Standards. New Project launched in the IE in 2007, SONIS (Safety of nuclear installations) is focused on the operational aspects of nuclear power plants, in particular maintenance, and the qualification and training of the maintenance personnel is of the particular interest of SONIS.

The information presented in the paper is the result of the thorough analysis of the OSMIR Data Base. This database is a compilation of recommendations, suggestions and good practices from OSART mission reports, and covers all missions from January 1991 to the most recent missions for which an official reports have been published.

It was found in several OSART missions that at some nuclear utilities human related factors including knowledge transfer are not properly addressed. The following deficiencies are the typical representatives of the shortcomings in training programmes which may lead to critical knowledge losses and not adequate competence of NPP staff:

- Lack of systematic job and task analysis as a basis for specifying the content of training programmes and assessment criteria;
- The refresher training is not based on the job specific needs and knowledge gap analysis;
- Insufficient details (e.g., description of training content, learning objectives, assessment criteria) of the training programme;
- Inadequate incorporation of lessons learned from external operational experience;

- Insufficient training in safety awareness and safety culture.

Many NPPs have well equipped Maintenance Training Centres with mock-ups of reactor, steam generator, reactor cooling pump, all types of valves (e.g. to train packing), control rod drives, rotating machines). This allows conducting effective training of maintenance personnel, however in some NPPs such equipment is missing. Main deficiencies in the maintenance training are that the maintenance training does not include lessons learned from experienced workers, from industry events, changes in plant maintenance programmes and approaches. Despite that the on-job training, which is the basis for the acquiring the adequate competence for some maintenance position, is not provided with job specific training in a facility workshops and does not ensure a transfer of knowledge.

The weak point of the training management is the assessment of the training results and acquiring knowledge. The lack of assessment of training effectiveness does not ensure that it will meet the quality standards for ongoing and perspective staff performance needs. In some cases the evaluation of training programmes focuses mainly on the numerical indicators (number of attendees, training events, training hours, etc.) and does not consider the quality of training delivered.

Common issue at the majority of nuclear power plants is the training of plant managers. Training programs for managers and supervisors are not always differentiated to focus on the competencies needed for particular jobs or levels of management. In many nuclear facilities there is a lack of formal programme to give all management and supervisory staff the full range of supervisory skills required to effectively manage the plant. Some managerial elements are missing in the training programmes, in particular, knowledge retention and transfer issues, the observation skills and identification of human performance deficiencies.

The information presented in the paper may be useful for the managers of the nuclear utilities and power plants to benefit from the experience of nuclear industry in the proper management of human resources to ensure the proper qualification of personnel and preservation of nuclear knowledge and experience for the sake of safe operation of nuclear utilities. The additional objective of the paper is to attract the attention of the nuclear industry to the IAEA OSMIR Data Base where the vast information on the subject is accumulated. The issues associated with knowledge transfer and personnel competencies identified by the OSARTs as well as the best practices in this area may serve as a good support in the development of training and knowledge management programmes for new nuclear facilities and improvement of the training programmes for nuclear facilities under operation.

HUMAN RESOURCES DEVELOPMENT: CAPABILITIES AND EXPERIENCE OF CNEA AND ITS INSTITUTES IN ARGENTINA

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The Argentinean Atomic Energy Commission (Comisión Nacional de Energía Atómica – CNEA) was created in 1950. CNEA and its related companies of the nuclear sector are presently active in several fields: operation of two nuclear power plants, construction of a third one, operation of several research reactors and critical facilities, production of Mo-99 from low enrichment targets (having world leadership in that field). Argentina has also exported, in the last twenty-five years, four research reactors (the last one, OPAL in Australia, attained criticality last year), and is active in the fuel cycle (having attained maturity in high-density and very high-density fuel for research reactors, among others), in radioisotope production and in nuclear medicine.

The successful attainment of these achievements has always been supported by an active policy of human resources development, either through "on the job" training activities guided by experienced professionals and sustained on a fellowship programme, or via institutes for under and postgraduate studies.

This programme not only satisfies CNEA demands, but also helps providing highly qualified personnel to the local industry and research institutions.

Nowadays, the perspective for nuclear energy is promising, but for many years nuclear activities had been loosing momentum worldwide. The nuclear sector became weaker, and CNEA was not an exception. However, it never stopped its activities in educational areas, knowing that many years are needed to form a solid professional in the nuclear field, and having the conviction that, for a sustainable development of the country, nuclear energy should necessarily be part of the supply. Nuclear engineers, material scientists and technologists, physicists, radio chemists, etc., ended up working in industries, universities and R&D institutions after finishing their education, instead of joining CNEA.

In 2006 the Argentinean government re-launched nuclear energy programmes. Funds are being provided for finishing the construction of the third NPP, for a feasibility study of a fourth one, as well as for life extension of the Embalse NPP, and for various projects in the areas of small reactors and fuel cycle.

As in other countries, in Argentina there is a need to accelerate the development of the nuclear workforce. New, young personnel are being trained and are joining the organization.

The number of students and fellowships devoted to nuclear careers was increased; young engineers and technologists are receiving fellowships for training in specific areas, in turn related to the ongoing projects.

Yet, the working force is still ageing, and consequently a strong plan to maintain, expand and recover technical capabilities is underway, based mainly on:

- Review of the present situation regarding human resources, their fields of expertise and their retirement plans.
- Identification of key knowledge areas, at present times and in the mid term.

- Identification of both active and retired people that could help in transferring the accumulated knowledge to the newcomers. Due to the large junior to senior staff ratio, grouped tutorship is being proposed.
- Identification of knowledge gaps or bottlenecks, in the frame of the new projects.

In few words, a concentrated effort of human assets development is being faced, to sustain the nuclear workforce for existing and future nuclear installations and for developing new designs, based on:

- A fellowship program of “learning by doing” which is under way for technicians, university students, doctoral and post-doctoral fellows. More than 200 fellows are presently being trained in CNEA laboratories, under supervision of staff members.
- Study fellowships for education in the Institutes created in alliance with national universities, whose faculty members are CNEA researchers and whose laboratories are CNEA facilities, including a research reactor mainly devoted to training:
    - Balseiro Institute: offers under and postgraduate studies in nuclear and mechanical engineering, and in various areas of physics, including medical, as well as training in nuclear applications. More than 250 nuclear engineers have been formed there, as well as an important number of physicists.
    - Jorge Sabato Technology Institute: offers undergraduate and postgraduate studies in materials science and engineering. Around 200 professionals have been formed there.
    - Dan Beninson Institute for Nuclear Studies: offers one year postgraduate programmes in nuclear reactors and its fuel cycle, and in radiochemistry and nuclear applications. They are mainly aimed to people directly involved in the nuclear field.

There are also courses to fulfil specific needs, e.g. welding, radiological protection, non destructive testing, radioisotope use and dosimetry, etc.

Since its very beginning, CNEA´s efforts in education have been opened to fellows from other countries, mainly from the Latin American region, sponsored by CNEA itself, by IAEA, by the Organization of American States (OAS) or by bilateral cooperation agreements.

At present, Argentina has significant means to provide the qualified personnel necessary for the growing of nuclear activities in the country, with capacities that can be offered to international projects on nuclear education. Based on our 50-year experience of international cooperation in this field, CNEA is willing to contribute to the worldwide effort in developing human resources for the nuclear future.

EXPLICIT KNOWLEDGE RESULTING FROM INTERVIEWS WITH THE EXPERTS IN THE ARGENTINEAN NUCLEAR REGULATORY AUTHORITY (ARN)

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A considerable number of ARN experts have been retiring for a number of years now, and it is estimated that by 2010 a significant number of them will no longer be working for the agency. We estimate that by then the 20 most important experts would have already retired. At present, ARN has a workforce consisting of 300 employees; with more than 100 of then having been recruited between 2002 at 2006. Unfortunately, from 1994 to 2001 very few people joined the agency. Those who will take over the positions of retirees, have either not been trained yet or are still in the training process. Such a phenomenon raises challenges and a number of issues that should be considered for the mid and long term. Knowledge Management was initiated as a way of facing the above-stated phenomenon.

In 2000, ARN had around 30 officers with a high level of expertise; these officers contributed and continue to contribute significantly to the regulatory activity both at a domestic and international level. By 2010, more than 20 of them will be in the process of retiring or will have already retired.

With a view to solving this problem, the methodology of “history of the learning process” implemented in a number of in-depth interviews with the experts has aimed at retrieving their knowledge and has also allowed us to elucidate a number of issues pertaining nuclear and regulatory knowledge and to detect that a number of institutional training programs, would be critical for efficiently training the new candidates who would ultimately take the places of retiree experts. Even though there are a considerable number of methodologies available to obtain implicit and tacit knowledge from people [1], the above-stated methodology is an example of the contribution to the nuclear sciences by humanistic tools.

The methodology of “history of the learning process” implemented with the technical assistance of Public Administration National Institute in 2006.

At an initial stage, those officers that qualified as experts were interviewed in the course of a week. Areas of involvement and roles played by ARN’s staff members were identified and officers who would be knowledgeable of such topics and roles were screened. A preliminary list of experts was created and necessary adjustments were made, as defined by some of the experts who had the chance of reviewing the list. The final list of experts to take part in the process was defined and in-depth interviews with them were conducted.

Initial interviews covered almost 40% of the total number of experts. Efforts were made to begin the interviewing process with retired experts; however, that largely depended on retirees’ willingness and availability. It was finally concluded that priority would be given to available staff members, certainly without disregarding the original list.

The interviewing methodology has allowed ARN to code tacit [2] and implicit knowledge resulting from experts’ statements. As a result of this technique and among a number of relevant findings, a possible training framework for new officers was identified and planned for the long term. Part of such training framework, aimed at developing officer competencies, may be summarized as follows: <u>For professional staff members with a hard science</u>

background: a) basic training, consisting of Radiological Protection and Nuclear Safety post graduate courses and English courses b) Supplementary training including refresher courses and attendance to national and international congresses; specialized training such as on-the-job training; presentation of research papers in congresses. c) Final Training, including tutorship of incoming staff members and teaching at ARN training and postgraduate courses.

For technical staff members with a hard science background: a) basic training, including the Course on Radiological Protection and Nuclear Safety for technicians and English courses. b) Supplementary training, including refresher courses, on-the-job training, and research. c) Final Training, consisting of tutorships and teaching activities.

Finally, for professional and technical staff members working in the administrative and humanistic areas: a) basic training, consisting of an *ad-hoc* course to introduce them to the ARN and to ARN knowledge, and English courses. b) Supplementary training, including attendance to national and international course and congresses, participation in technical meetings, research activities, etc.

This technique, consisting of an in-depth interview with the experts of a given institution, is probably one of the most straightforward ways of getting access to the institution's implicit and tacit knowledge. In addition, such knowledge can be shared and disseminated among a sizeable number of people, since it is not limited to knowledge transfer between two subjects but it rather aims at expanding knowledge across a given institution.

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STUDY ON THE ATTITUDE OF NUCLEAR TECHNIQUE USERS

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This paper presents the results of a study on the attitude of nuclear technique users towards nuclear applications. The study was performed in Cuba during the period 2004-2006.

This study responds to the need of the Cuban Nuclear Energy Agency and Advanced Technologies to determine the public awareness and acceptance regarding nuclear applications and to identify the information needs of the public for communication design strategies.

On the other hand, studies performed by the International Energy Agency on the potential market for non-electric applications of nuclear energy in different countries, shows the different publics in Cuba with a non-defined attitude towards nuclear energy at present [1].

Considering this fact, a production research was designed and implemented with a social and psychological diagnostic character that allowed to identify the needs of the public object of study and to elaborate a communication strategy for the Cuban Nuclear Energy Agency and Advanced Technologies. This communication strategy was designed, for the first time, from the viewpoint of the public that is the object of this research.

Specialists and technicians were selected as the object of study public, also identified as a priority in the IAEA–TECDOC-1076 [2]. This public comprises all those people using radiations in their work place under the supervision of regulatory authorities, i.e. users and operators of nuclear technologies in the country in industrial institutions, heath care, agriculture and in the environment.

The first stage of the research was to elaborate a methodology with specially designed tools for the mentioned study. The methodological research tools used in the research were a questionnaire (survey) and a semi-structured interview: The latter was aimed at obtaining complementary information of qualitative character [3]. The analysis of the results was made using the SPSS statistical processor.

The methodology allowed assessing the opinion of users regarding nuclear applications in terms of agreement or disagreement, acceptance or rejection, based on the questions answered on their knowledge, assessment and behaviour.

The main results of the study were the following:

- The image of nuclear applications is related to health and medicine (44,4), radiations (10%), negative associations 4,4%.
- 100% of the surveyed specialists and technicians accept the use of nuclear techniques and consider it as **very important** for medical diagnosis (94%), cancer therapy (93%) and for sterilizing medical tools and/or appliances (67%).

- The main information channels are the workers of the nuclear energy branch (74%), the educational system (72%) and in 3rd place the mass media (57%).
- The information on the use of nuclear techniques is **insufficient** in the country, (80%).

The research is a reference tool for future studies on public opinion related to nuclear energy in the country and it allowed elaborating a communication strategy for the Cuban Nuclear Energy and Advanced Technologies Agency which will favour its work as the leading authority of the Cuban nuclear programme.

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THE BELGIAN NUCLEAR EDUCATION NETWORK, 5TH ACADEMIC YEAR

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In a country where a substantial part of the electricity generation will remain of nuclear origin for a number of years, there is a need for well educated and well trained engineers in this area. Public authorities, regulators and industry brought their support to this initiative. In 2001, the Belgian Nuclear Research Centre SCK•CEN and five Belgian universities signed a consortium agreement to set up an education programme in nuclear engineering. This academic year, a sixth university, ULB, joined the programme. The universities involved are now: KUL (Leuven), UG (Ghent), VUB (Brussels), UCL (Louvain-la-neuve), ULg (Liège) and ULB (Brussels). These seven partners have engaged themselves anew to provide students and young-professionals with a high-standard nuclear engineering programme.

The BNEN academic programme is a one-year (60 ECTS) Master-after-Master programme open for holders of a Master degree in engineering. The programme consists of ten courses to be followed mandatory (41 ECTS), the opportunity to select a number of advanced courses at will (up to 4 ECTS worth) and a Master thesis (15 ECTS). The subjects of the courses range form nuclear physics, nuclear reactor theory, nuclear thermo hydraulics to reactor plant operation and control, radiation protection and safeguards and nuclear materials. It also includes courses on nuclear energy and the nuclear fuel cycle. All courses are given in a modular fashion, i.e. the students get a course in the duration of one up to three weeks of continuous lectures and lab sessions. Attention is indeed paid to the fact that most courses are not only theoretical ones, but many of them have exercise sessions and laboratory sessions associated with them. These sessions are organised and thought by the scientific staff at SCK•CEN.

The number of students enrolling for the BNEN has seen a serious growth since the start of the initiative. The programme does not serve only "full-time" students, i.e. people having just obtained their Master degree and decide to take a one-year degree extra. Also a lot of young-professionals employed at different industrial stakeholders (nuclear power plants, regulatory body, engineering bureau …) enrol for the programme. They typically spread the one-year programme over two or three years to combine their job with these studies. It is clear they get the full support from their employers, sometimes because they need the degree to be allowed in crucial positions in the company.

The BNEN programme is also a founding father of the ENEN programme (European Nuclear Education Network). Students are encouraged to take up courses in a foreign university to broaden their views.

Thanks to the modular approach, the courses are also open for young (but also not-so-young-anymore) professionals who wish to refresh or deepen their knowledge on nuclear engineering subjects. Admission to the courses and exam is treated on a case-by-case basis by the BNEN Steering Committee.

The BNEN Steering Committee is committed to continue the nuclear engineering programme offering a high-level education. Within the 6th European Framework project, a Self-Assessment Report was written indicating both strong and weak points of the programme.

The Steering Committee has also contacts on a one-to-one basis with industrial stakeholders who send their employees to follow the programme. Based on this feed-back the Steering Committee can remediate any shortcomings in the programme or the organisation. However, the Steering Committee is strongly convinced that the BNEN programme must remain an academic program – and not an industrial training programme – of a high standard.

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ASSESSMENT OF RADIATION PROTECTION TRAINING NEEDS AND CAPABILITIES IN EUROPE: RESULTS OF THE ENETRAP SURVEY

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Maintaining a high level of competencies in the field of radiation protection is crucial for the future safe application of ionising radiation and to ensure the protection of workers, the public and the environment.
Although working with a variety of responsibilities and specific professional aims, practitioners dealing with applications of ionizing radiation have three common needs with regard to radiological protection:

- basic education and training providing the required level of understanding of artificial and natural radiation;
- a standard for the recognition of skills and experience; and
- an opportunity to fine-tune and test acquired knowledge on a regular basis.

The wide variety of the national approaches of the E&T programs in radiological protection in Europe hampers a common European methodology concerning these issues. This is particularly true for the Qualified Expert. Although, in this specific case, the fundamentals of the E&T programs are given by a European directive, the national differences in for instance, level, duration, subjects, practical and theoretical proportions in a program etc. create a barrier for the mutual recognition of this expert. The development of a common European radiation protection and safety culture and, based on that, the mutual recognition of radiation protection courses and the acquired competencies of radiation protection experts becomes crucial in a world of dynamic markets and increasing workers' mobility.

A sustainable Education and Training (E&T) infrastructure is an essential component to combat the decline in expertise and to ensure the continuation of the high level of radiation protection knowledge in the future. Such infrastructure has to be built in such a way that both the initial training ("Education") and the unceasing maintenance of the level of competencies ("Training") are available. In answer to the need to develop a common European radiation protection and safety culture and, based on that, the mutual recognition for radiation protection courses and the acquired competencies of Qualified Experts, the ENETRAP project is working on a European harmonized approach of E&T programs in radiation protection.

In a first phase of the ENETRAP project; a questionnaire was set up, the objective of this questionnaire being to elicit detailed information which will enable us to:

- assess the actual training needs in the EU Member States and Candidate States;
- understand the various regulatory aspects and consequently propose minimum requirements for mutual recognition of RPEs and RPOs;
- collate details of the various training and education activities available in the EU Member and Candidate States, and
- review the content, structure and methods of these training and education activities.

Hereto, an extensive list of questions was set up addressing the following topics:

- numbers of RPEs;
- identification of practices;
- national capabilities for education and training in radiological protection;
- regulatory requirements and
- recognition.

This questionnaire was sent out to 31 countries, i.e. the European Member States, the Candidate States, and the Associated States Norway and Switzerland.

This paper will summarize the results of this questionnaire and the implementation these results into the construction of the E&T programmes, namely the European Master in Radiation Protection (EMRP – to start in September 2007) and the ENETRAP training scheme, being a revision of the Saclay based European Radiation Protection Course ERPC.

A preliminary programme of both initiatives uses a modular approach and puts forward 2 parts : a common basis, and a series of specialized modules on occupational radiation protection in nuclear power plants and fuel cycle industry, the medical sector, non-nuclear industry and research laboratories, waste and disposal sites, etc…

The EMRP and ENETRAP training scheme are planned to run (partly) in parallel, so that an overlap can be made between certain modules. This innovative construction allows close contact and enhances discussions between students and professionals.

The theoretical program needs to be extended by an on-the-job training (OJT) period and the possibility to follow (parts of) the modules via e-learning needs to be implemented. ENETRAP also strongly suggests to cooperate with expert networks such as EURADOS and the ALARA network who are willing to "foster" the chapters dealing with their specific competences.

The final program of the ENETRAP training scheme needs to be developed in such a way that it gives a common basis which meets as much as possible all national regulations and thus will receive a recognition from the participating European countries. Standardized material should be provided.

The results of the ENETRAP project will be transferred to the European umbrella organization EUTERP which could deal with issues such as recognition of courses and certification, mobility of students and teachers, sharing of teachers and teaching facilities etc…

A TRANSDISCIPLINARY APPROACH TO EDUCATION AND TRAINING IN RADIOLOGICAL PROTECTION AND NUCLEAR ENGINEERING

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This paper aims at developing an argumentation for an approach to education and training in radiological protection (RP) and nuclear engineering that is broader than the 'classical' acquiring of factual knowledge related to physics and regulation. As for most other areas where applications of a technology are connected to a certain risk, the complexity of applications of radioactivity and nuclear technology has generally technical as well as social dimensions.

As well the nuclear worker as the policy maker, or any other person working within an application field of ionising radiation, could face situations requiring action where, apparently, the available factual knowledge does not lead unambiguously to a way forward that is 'justified enough' in relation to the potential risk. And if the solution *would* be justified for him/her, it could be that others involved have different opinions. Having this in mind, it is clear that education and training in RP - seen as a continuous learning process - should elaborate on as well the socio-technical complexity of 'risk assessment' as on the conditions and methodologies to 'find a way out'.

Rather than dwelling on methodologies for the organisation of this 'broader' education and training, this paper will analyse elements of complex problem solving and make a link to ethical aspects in order to found the argumentation for this broader approach. We will highlight how the key ideas related to complex problem solving have been translated already in specific methodologies in socio-political science and epistemology.

Based on the philosophical reasoning and on the related (existing) methodologies, we will then argue that the theory and practice of RP could and should develop as a systematic and interactive practice of a diversity of disciplines and skills, and that RP, in this sense, has the potential to serve as a key example of a transdisciplinary interaction of science with society.

The paper then looks at the specific issue of justification and optimisation in the field of applications of low level ionising radiation, and sheds the light on a new approach to optimisation and on some challenges within the scientific community and the broader society.

It will conclude with some examples of the application of the outlined transdisciplinary approach as developed by the Belgian Nuclear Research Centre SCK•CEN.

EVOLUTION OF NPP PERSONNEL TRAINING: TRENDS, NEW NEEDS AND PERFORMANCE IMPROVEMENT FOCUS

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INTRODUCTION

During recent decades new training needs and demands for improving human performance have appeared in the nuclear industry, including the following:

- integrated management systems;
- more demanding safety requirements;
- implementation of emergency procedures; more attention to emergency preparedness; training on the beyond design basis accident (BDBA) management;
- challenge to increase both NPP and training efficiency and effectiveness;
- equipment and workforce ageing;
- use of training as a tool for preservation of knowledge;
- modernization of plants;
- new designs;
- upgrades of training tools including full-scope simulators;
- programmes for optimization of NPP maintenance;
- a growing number of decommissioning projects;
- availability of new computer-based training technologies;
- increasing attention to the competence of NPP managers;
- development of infrastructures in countries expanding their nuclear power sectors or initiating nuclear power programmes.

The opening of electricity markets has led some nuclear power plant operating organizations to be under serious economic pressure with a demand for cost reductions and performance improvements. These factors necessitate NPP operating organizations to make their training more cost-effective. As the nuclear power industry continues to be challenged to maintain high safety standards, while responding to the pressures of more competitive energy markets, it becomes more important than ever to maintain excellence in human performance and ensure that NPP personnel training adds value to the organization. It has been increasingly recognized that in order to achieve excellence in human performance, in addition to technical competencies it is also important to focus on open communication; teamwork; leadership; problem resolution; safety consciousness; business performance; ethics and professionalism.

TRAINING TRENDS

Operational and safety performance indicators have shown significant improvements in both NPP and human performance in the past twenty years. Training and human performance initiatives have contributed to these improvements; while the following new needs and trends are being addressed:

- Training focus (improvement of human performance).
- Training regulations, policies and procedures (integration into plant Management System; standardization of SAT procedures).
- Target job classifications (maintenance, management and contractor staff).
- Training for various NPP life cycle phases (decommissioning; construction and commissioning; plant life management; ageing management; long-term operation; plant modernization and uprates).
- New NPPs (rising expectations; lack of skilled personnel; innovative designs; small and medium size reactors).
- Personnel competencies addressed in training (operational decision making; diagnostics; risk-informed decision making; professional ethics).
- Training methodology (wide but uneven use of SAT; use of job hazard analysis, human reliability assessment, project preview, PSA).
- Training methods (e-learning; structured pre-job briefings; coaching).
- Management of training (integration into NPP Management Systems; evaluation of training effectiveness).
- Changes to training departments and centres (decentralization due to the needs in mostly continuing training; sharing; communities of practice; centres of excellence; specialized training centres).
- Simulators (upgrades; various types of simulators; use for preservation of knowledge; job classifications other than control room shift; plant modernization projects; support of plant design and commissioning).
- Computer-based training (up to 30 % of training; Learning Content Management Systems; multi-functional use; a tool for knowledge preservation).
- Role and competence of instructors (changing the role to Performance Consultants).
- Development of NPP management competence (integrated approach to selection, training, performance assessment and development).

SUGGESTIONS FOR FUTURE COOPERATION

To effectively change human performance in the workplace, training must be a strategically applied tool supporting behavioural change and results-based training. A new IAEA document entitled “Increasing Training Effectiveness and Improving Organizational Performance in Nuclear Power Plants: Management Perspective” is being developed to provide Senior and Line Managers with techniques and practices to systematically evaluate the effect of training on individual and organizational performance. Pilot sessions for the application of this document at working facilities are planned. These sessions will focus on taking Line Managers from gauging the success of the training programme in terms of learning scores to monitoring the success of the training through measurable and observable predetermined goals grounded in workplace behaviours. The application of a systems approach to the Line Management System will help move Managers toward thinking holistically about the common goal of meeting individual and organizational needs rather than treating human performance as a simple, linear, cause and effect relationship.

INFORMATION SOURCES

Useful information; publications; knowledge preserved from various projects, workshops and meetings can be acquired through the Electronic Nuclear Training Catalogue ENTRAC http://entrac.iaea.org.

DEVELOPMENT OF NUCLEAR ENGINEERING EDUCATION IN JORDAN

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The establishment of a Nuclear Engineering program is another step in Jordan's efforts to develop its nuclear infrastructure, and to introduce nuclear power as part of its energy mix. Nuclear energy offers a promising approach to meeting Jordan's energy needs—an approach that would reduce our dependence on oil imports, create jobs, raise the standard of living, and alleviate the burden on the national budget. Nuclear energy will also be required to provide electricity to fulfil growing electrical demands, water desalination, and hydrogen production.

The Nuclear Engineering department at Jordan University of Science and Technology (JUST), is the first and only such department/program in Jordan. The university it self is a scientific university with more than 17000 undergraduate students and 1000 graduates, including more than 3000 international students from 41 different countries. Approximately 6,000 students are enrolled in the college of engineering.

Our goal is to establish a world class department, which will enhance nuclear knowledge in Jordan, and will graduate qualified engineers that will help in the design, building and running of Jordan's first nuclear power plant. It is also our goal to serve as Jordan's leading nuclear research center.

The department is planning to start accepting students in the next academic year (2007/2008), which starts in September 2007, it will accept students both in the freshman and sophomore levels (first and second year). Thus graduating its first class in 2011, this is the period that Jordan will be in the building phase of its first nuclear power plant. Consequently nuclear knowledge transfer from nuclear suppliers and contractors of developed nations to our graduates working with them will be more realistic.

The objectives of the nuclear engineering program are to educate students in the fundamental subjects necessary for a career in nuclear engineering, and in the basics of nuclear technology, radiation measurement, and nuclear reactors, and to train students in the basics of instrumentation use, laboratory techniques, and data acquisition, interpretation and analysis.

Four elements will determine the success of this department and whether it will provide top quality education that will lead to realistic teaching instruction; Curriculum, Faculty, Facilities, and Students, each are discussed in this paper.

The curriculum focuses on nuclear power engineering, in particular nuclear power from fission reactors. World class courses are anticipated to be offered, and the curriculum is set at the ABET standards and it is expected that the department will seek to obtain its accreditation.

The curriculum gives the student a very strong background in basic sciences and engineering, the curriculum also prepares the graduate for work in many areas where a broad technical background is more important than specialization in a specific field.

The program is designed to fulfil Jordan's needs for nuclear engineers and scientists, thus the students populace and department size should remain within the boundaries that serve this purpose. It is imperative that the university prepares a pubic relation campaign, to introduce the program to future students and their families in order to attract the top high school graduates.

The quality of teaching at any institution depends to a large extent upon the quality of the faculty and academic staff. To ensure a top quality educational program, the department has to be staffed by faculty and academic staff whose graduate and undergraduate work is in nuclear engineering, or graduates with practical experience in the nuclear field, and who have gained enough nuclear knowledge, to be transferred to students.

The enormous challenge that will face the university will be staffing the department with such high calliper people. The present University salary system where all professors whether they teach music, history, or rocket science earn the same salary, is obsolete and would definitely undermine the department, and hinder its success.

The department will be equipped with all necessary labs and facilities for the students training, to support the curriculum, and for carrying on research. The department plans to be the leading nuclear research center in Jordan. The department is currently working on establishing the following laboratories: Radiation Detection and Measurement Laboratory, High Speed parallel computational Lab, Sub-Critical Reactor Lab, Graphite Pile Laboratory, Environmental monitoring Laboratory, Thermal sciences Laboratory, Research and Training Reactor (RTR).

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THE SOUTH AFRICAN YOUNG PROFESSIONALS ON SKILL TRANSFER, KNOWLEDGE MANAGEMENT AND NUCLEAR PUBLIC EDUCATION

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The South African Young Nuclear Professionals Society (SAYNPS) was established in 2002 after the Second Biannual Conference of the International Youth Nuclear Congress (IYNC) in Daejong, South Korea. Its main objectives are to promote skill development and knowledge transfer from experienced nuclear professionals to the young generation, preservation of nuclear knowledge and public education. These objectives are very crucial since many nuclear experts are about to retire and could leave the industry with shortage of skill. A document is being developed to address strategies that can be used to close the gap between the young less experienced and experts in the field. SAYNPS holds a conference every year and this provides young professionals with a platform to share their experiences and knowledge. Workshops and information sessions in the work places are very much encouraged because young professionals can learn a lot and perfect their knowledge from positive criticism. Newsletter and website will be established as forums for young professionals and experts in nuclear industry. The major challenges will be willingness of experts to share and making sure that all knowledge is captured, stored and kept up to date. Futhermore, the mammoth task is to deal with is the negative sentiments about the safe usage of nuclear technology which won't be easy to achieve but SAYNPS is committed to seeing the process through. Government agencies in South Africa regularly organize campaigns that promote science and technology. SAYNPS encourages its membership to play a role in these campaigns through exhibitions and school outreach. These campaigns are done to educate the public in general, science teachers and school kids about the benefit of the safe usage of nuclear technology and also to encourage kids to follow careers in nuclear.

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THE NATURE OF EXPERTISE AND HUMAN RESOURCE FUNCTIONS SUPPORTING EXPERTISE IN NUCLEAR INDUSTRY ORGANIZATIONS

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The nuclear industry worldwide faces the challenge of preserving the existing expertise, competence and knowledge despite of the ageing workforce and upcoming retirements. Challenges are also imposed by the reducing amount of new recruits and students entering the nuclear industry, which amounts to fewer young professionals that have the potential to become nuclear experts in the future. Although many other industries share similar challenges, the preservation of expertise in the nuclear industry is even more important due to the safety-critical nature of the nuclear operations and the special characteristics that high-reliability organizations such as nuclear power plants have.

As a response to the risk of knowledge loss, nuclear organizations have engaged in knowledge capturing efforts. New information systems and organizational practices have been implemented to safeguard nuclear expertise. Recently, IAEA has proposed nuclear organizations to design and adopt people-centered programs that encompass themes such as workforce planning, recuitment, training, succession planning, leadership development and knowledge management [1]. Thus, in order to address the current risks to nuclear expertise, attention should be focused on these different areas and corresponding human resources (HR) functions within the nuclear organizations.

Our paper presents results from a project which examines the nature of expert work and human resources (HR) functions that support the development and preservation of expertise. The study adopts a qualitative cross-sectional case study design. Two organizational units from different nuclear industry organizations have been selected as cases. The research data will be gathered in April-May 2007 and preliminary results will be presented in the International Conference of Knowledge Management in Nuclear Facilities, in June 2007.

The main data will comprise of thematic interviews to experts, their managers and HR representatives. Altogether approximately 25 interviews for experts will be conducted. The aim of these interviews is to disclose e.g. how the experts themselves describe their expertise and their expert role, what kind of support they need in maintaining and developing their expertise as well as what skills and skill sets they consider to be critical in the future. Approximately 5 interviews are carried out for managers. These interviews set out to explore the managers’ role in allocating and designing human resources and their insights on the current HR practices supporting the development and preservation of expertise. About 3 HR representatives will be interviewed to uncover how HR functions, such as recruiting and training, operate currently. The HR functions that are used in the nuclear poer organizations are then compared to HR process models and designs from the human resources management (HRM) literature.

The study contributes to the HRM body of knowledge from a functional, micro level perspective, exploring the impacts of HR practices on individuals rather than on corporations or business units (a strategic, macro level perspective). Furthermore, rather than studying one individual HR practice, we treat multiple HR practices as a system in order to uncover how individual practices complement, substitute for, or even conflict with other practices. [2] As a result, we expect to produce new understanding about the nature of expertise in the nuclear industry and discover new innovative ways to support the development, preservation and sharing of expertise.

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SOME ASPECTS OF DEVELOPMENT AND IMPLEMENTATION OF E-LEARNING IN NUCLEAR INDUSTRY

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Information technology has enabled organizations to re-engineer the way they operate. New infrastructures allow organizations to take advantage of the transactional and communication capabilities information technology provides.

During last decade international attention to nuclear industry dramatically increased. It accelerated already started process of implementation great number of innovations and modifications in existing plants and construction and commissioning of new units. As the number of modifications and innovations increased the volume of information increased as well and became fragmented. The sheer volume of information could be overwhelming. At the same time due to workforce ageing and distorted image of the profession the smooth process of generation substitution has been interrupted. The need to identify, elicit, preserve and disseminate important pieces of knowledge that enable effective operation in the interest of nuclear sector became critical. In order to meet this challenge new approach needed to be implemented. Turning information and data into knowledge became a prime priority. The most appropriate concept which could cover this enormous amount of information and data could be a knowledge management. Without such system staff spends large amounts of time reinventing the wheel and often repeating the past mistakes. Knowledge management enables the enterprise to maintain, develop, and distribute the knowledge expertise of its people.

Basic and most powerful instrument for establishing of such system are various applications of information technology. One of them is e-learning. E-learning and knowledge management have several features in common. Both deal with knowledge exchange and creating communities where knowledge is shared. Knowledge management is particularly challenged in attempting to explicate, share, and leverage tacit knowledge. Interactive nature of e-learning creates environment supporting sharing culture and transfer of tacit knowledge to the younger employees.

Knowledge that has not been articulated represents a lost opportunity to share and leverage that knowledge. If competitors have articulated and shared similar knowledge throughout their organization, they may obtain competitive advantage.

There are another intersection between e-learning and knowledge management – learning objects repositories. Learning objects could be viewed as reusable online learning resources. Creating central repositories of reusable learning objects is serving the needs of both e-learning and knowledge management.

The learning objects or knowledge elements as they are sometimes called represent a form of online content. The benefit of a learning object rests in the principle of "develop once, use many" such that the same learning object can be linked and appropriately used in multiple places.

Using e-learning tools you can create and store knowledge elements or learning objects in a relational database that's accessible plant-wide.

Distributing knowledge via e-learning system allows sharing culture to overcome traditional hoarding, just making knowledge acquired by experience more accessible.

In this article a small fraction of the knowledge management system, which is in the process of implementing in Kozloduy NPP, will be described. It is a new developed e-learning system. Multiple learning objects are accessible plant-wide via local intranet.

SUSTAINING NUCLEAR FUEL SCIENCE AND TECHNOLOGY BASE

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To fulfil energy demand, the Indonesian Government has made efforts to optimize the use of various-fossil and non fossil–potential energy resources in synergy (energy mix), which is stated in national energy policy. According to national energy policy, Indonesia is going to use nuclear energy for electricity supply, and up to 2025, the use of nuclear energy is projected at about 2% of the total primary energy or 4 to 5% of the national electricity supply. This energy demand is described in NPP road map (picture 1), which consists of NPP preparation, construction and operation up to 2025.

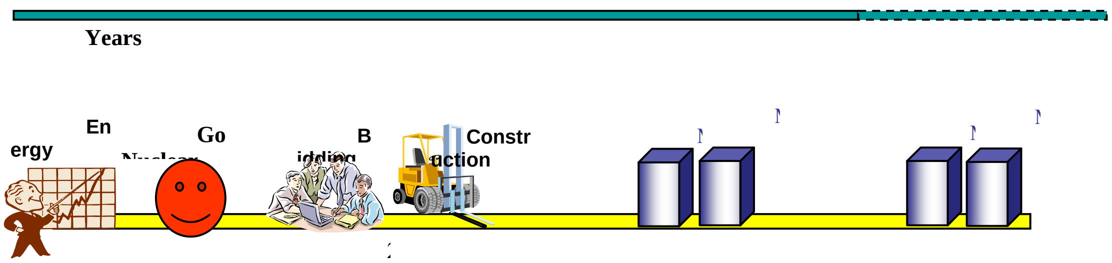

Fig 1: Road map Indonesian NPP

To sustain the activity of nuclear power plants, the continuity of nuclear reactor fuel supply is an absolute necessity; therefore, it will become industrially prospective and have an effect on national industries. As a nuclear research center and guidance in nuclear energy system in Indonesia, Batan also plays a role to promote this prospect and to increase the national content at NPP construction. In this point of view, Batan should have the competency especially in nuclear fuel cycle technology, and in this case PTBN is viewed as the competent center since PTBN's main task is to conduct the development of Nuclear Fuel Technology.

This competency is performed as mastering its science and technology base. In this case, PTBN is noticed to have the capability to function suitably since PTBN is equipped with documents for fuel fabrication industry such as bidding, construction and commissioning and qualified man power.

Basically, PTBN does not have the mandatory to operate nuclear fuel fabrication commercially. However, PTBN has the capability to prepare competent man power through training and coaching in nuclear fuel fabrication. In fact, the present condition shows that some of the equipments does not function properly or are not utilized optimally or are not operable. Besides, the process documents available have not yet validated and qualified, and the man power is not qualified yet.

Moreover, some of the employees who are experienced and knowledgeable in nuclear fuel research are going to retire. Meanwhile, they have not trained the junior employees—causing a big gap in skill and experienced. Therefore, since 2003 PTBN has prepared some programs to solve those problems. The goal of the programs is :

- BATAN, especially PTBN, plays a role as “center of excellent” in nuclear fuel technology; this is characterized by mastering its science and technology base.
- Documents preparation for nuclear fuel industry construction.
- Provision of qualified man power for nuclear fuel industry operation

So far the programs has shown positive progress such as the implementation of revitalization for several equipments, testing laboratory accreditation, preparation for calibration laboratory accreditation, operator coaching, nuclear fuel research development, active participation in INPRO and the implementation of total quality management system in accordance with IAEA code and guidance.

RUSSIAN NAVY PERSONNEL TRAINING IN NUCLEAR MATERIAL ACCOUNTING, CONTROL AND PHYSICAL PROTECTION

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The Project on the upgrades of the Nuclear Material Accounting, Control and Physical Protection systems (MPC&A) in the Russian Navy (Navy) started in March 1995 when the Commander-in-Chief of the Russian Navy proposed the Kurchatov Institute Russian Research Center (KI RRC) to carry out joint activities in the upgrades of MPC&A systems for the storage and management of nuclear materials in the Russian Navy. The U.S. Side also proposed a joint work in this area. After several meetings and discussions at the working level, in July 1996 the U.S. DOE Secretary, a Russian Navy representative and the KI RRC President signed a joint statement on the conduct of the work in this area.

The MPC&A Project in the Russian Navy is focused on the upgrades of the physical protection, control and accounting systems of nuclear materials starting from the time of their receipt by the Navy till their loading into Navy reactors. Additionally the Project includes the development of regulatory documents and Navy personnel training courses that are required for the effective operation and maintenance of the upgraded MPC&A systems.

The Paper describes the beginning and further development of the MPC&A training program for the Russian Navy within the framework of the cooperation between the Navy, the KI RRC and the U.S. DOE. The Paper also covers the creation of Kola Training and Technical Center intended to support the nuclear material physical protection systems installed at Navy sites of the Northern region. One of the goals of the KTTC is the Navy personnel training evolved in the operation and maintenance of these systems. The KI RRC was responsible for the KTTC construction, equipment, as well as for the development of the training and methodological documentation for the training courses and for the training of the trainers. The Paper presents information on the KI RRC activities related to the establishment of the KTTC training base.

Moreover at preset the Russian Federation develops the nuclear material MPC&A Culture Program (nuclear material security culture), and the Paper briefly covers problems of the MPC&A Culture Program in the Russian Navy.

NEW DIRECTIONS IN UNIVERSITY NUCLEAR ENGINEERING SUPPORT

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The Office of Nuclear Energy has supported university nuclear engineering education for over a decade within a program typically known as University Programs. Prior to the mid 1990's support for nuclear engineering education could be found not only in the Office of Nuclear Energy but also in the Office of Energy Research, now the Office of Science. Although some of the current programs were present in those two offices, there was little coordination between the offices and the Department of Energy did not speak with one voice when interacting with university engineering and science departments engaged in nuclear education.

By the middle of the 1990's, the Office of Energy Research had terminated its involvement in nuclear engineering education and the Office of Nuclear Energy assumed responsibility for programs such as Reactor Sharing, Reactor Instrumentation, Fellowships and Scholarships and Nuclear Engineering and Education Research. Previously in 1992-1993, the Office of Nuclear Energy had introduced a new program, Matching Grants, in concert with Commonwealth Edison (Exelon) where the private sector matched the Department's funding contribution up to a predetermined ceiling.

By the late 1990's, surveys of universities demonstrated that nuclear engineering undergraduate and graduate programs were severely under-populated and were experiencing yearly declines in their student population. Clearly, more had to be done not only in terms of new programs to attract students to nuclear engineering but to educate the public, especially students, about the need for nuclear engineers and the promising careers offered in the nuclear field from the standpoint of technical challenge and remuneration.

It was at this point in the late 1990's and early 2000's that DOE assumed a more active role in assisting the universities in attracting more students. Various methods were employed to accomplish this including: funding outreach by the American Nuclear Society; initiating new nuclear education programs; developing ways to attract underserved populations (minorities and women) to nuclear; coordinating DOE/NE efforts with organizations such as the Nuclear Energy Institute; chartering the University Working Group enabling universities and research reactor representatives to play an active role in assisting DOE/NE in improving programs and approaches to nuclear education; and engaging the universities, laboratories and nuclear industry in partnerships via a new program entitled Innovations in Nuclear Infrastructure and Education.

More recently, work has been undertaken on additional outreach initiatives including the Harnessed Atom instructional program for high school students in classes such as advanced Physics, Chemistry and Biology, as well as surveys of high school students to determine what factors influence their career choices. Other surveys have polled current and former nuclear engineering undergraduate and graduate students in an effort to determine the effectiveness of the DOE university programs. The results of these initiatives have been a quadrupling of the undergraduate student population and a doubling of the graduate population studying nuclear engineering and nuclear related disciplines and a leveraging of DOE funding that has served as a catalyst for non-DOE funding.

Now, as we approach the end of the first decade of the new millennium, DOE is looking for different ways to continue to serve nuclear engineering education so that universities produce graduates educated in nuclear concepts that are sought by national laboratories, industry, universities and government. The evolution of this new approach is now occurring. Shortly, we will embark on a new program for supporting nuclear engineering education that will revolve around our mission directed R&D programs. Universities will assume a larger role in our research and infrastructure activities such as support for reactors, students, and faculty will be imbedded (instead of being stand alone and unrelated as it is now) in the research proposals submitted by the universities. The research awards to universities will not only advance our mission-related R&D but will provide the necessary support to continue to attract students to a nuclear engineering course of study thereby providing a permanent pipeline of new engineers to replace the workforce that demographics show us will be retiring over the next 5-10 years.

WAYS TO PRESERVATION AND MANAGEMENT OF NUCLEAR KNOWLEDGE ON WWER REACTOR PRESSURE VESSELS

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Nuclear knowledge preservation activities are ongoing in the EC-JRC Institute of Energy with the intention to collect all available information about reactor pressure vessels of WWER type reactors as well as to analyze and summarize the most important items and issues. This activity is in line of the European Community FP6 projects PERFECT (Prediction of irradiation damage effects on reactor components) and mainly COVERS (Coordinated action on WWER safety) in which all WWER operating countries also take part. Actually, the electronic database was created and is accessible for young or expired researchers in this area. The access is recommended via ODIN (Online Data and Information Network) https://odin.jrc.nl/doma. After registration you can enter the WWER DoMa-db: "Database of references for knowledge management and Preservation on WWER reactor pressure vessel". For the access to confidential information you have to ask an indicated administrator.

For the project, more than twenty precise selected specialists, mainly from WWER operating countries, have been asked to help with the collection of such mostly rare publications. It is clear that a large number of publications, since the very beginning of the research studies and from the first years of reactors operation, were published in Russian as well as in other national languages (Czech, Slovak, Hungarian, Finish etc.). This makes the situation complicated for most of foreign experts, and today, also for most of WWER reactor operators in individual countries. A large number of publications was prepared also in other languages and were sent not only to international, but also to some national journals as well as presented in many national conferences/workshops etc. proceedings which are now very complicated to find from abroad.

Authors have been asked via national experts for their full lists of publications dealing with material properties of WWER reactor pressure vessels, and as a first step, it is the intention to concentrate on studies and results related to the irradiation damage and testing for these type of steels as this practically determines reactor pressure vessel lifetime and it is the reason of most vessel problems. As a second step, full texts of the relevant publications have to been required when not be possible to find them in standard libraries. The material and further knowledge has been discussed in the leading group in JRC-Petten and of course, this database of the bibliographies (supported by full text of all included publications with abstracts in English and in electronic format) will be served and will be available to all authors immediately, thus it will also help the authors for current work and studies. Further, these materials will serve as a basis for elaboration of a state-of-the-art report on radiation damage in WWER reactor pressure vessels steels that will be prepared with an active participation of all active authors. The structure and content of the reports will be prepared in the workshop where the participating authors will be invited.

In the field of reactor pressure vessel (RPV) embitterment, a generational gap is slowly appearing with regard to in depth knowledge of materials behavior and related neutron embitterment issues. This is due mainly to the fact that the experts who took part in the design, construction and commissioning of the nuclear reactors are now approaching retirement, if not already retired, and/or changed job for different reasons. In addition, for the

Russian design RPVs a significant fragmentation of the knowledge took place with the dissolution of the USSR and the dislocation of the various WWERs into several Member States; including: Hungary, Slovakia, Check Republic, Bulgaria and Ukraine. Significant knowledge on WWER-440 is also available in Finland and of course in Russia. In the previous decades, many of national experts were involved into following international projects.

The nuclear knowledge management is realized not only via database creation or education process during undergraduate (Bc.), graduate (MSc.) and postgraduate (PhD.) study but also via specialised training courses in a frame of continuous education system, research activities and projects, workshops seminars, ect. For illustration of the actual status and possibilities, the Slovak nuclear knowledge model is used. Unfortunately, decrease of number of employees in nuclear and ”human ageing” of experts seems to be a serious problem not only on world but also in Slovakia.

ANALYSIS OF THE MOTIVATIONS OF THE RETIRING EXPERTS FOR KT IN INR

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The organizational strength does not come from knowledge of the past per se; rather, it comes from the ability to regenerate knowledge of the organization, its processes and its markets [1]. Our analysis is intended to answer: ‘what is INR core competency?’ ‘what are the characteristics of the actual INR market, and what are the predictions?’ ‘what did we learn from our history?’ ‘what are the optimal methods to solve INR problems in KM?” For the next period, since many experienced researchers should retire in 5-10 years, the knowledge preservation (KP) in INR is a stringent aspect. The problem is connected with the divergence between the organizational interests (effective and efficient KT) and the interests of experienced people (do not transfer the important part of their knowledge). In order to solve this sore point we performed a questionnaire-based investigation with the intention to obtain the general matrix of interests. The final objective of our work is to harmonize the organizational and retiring personnel interests. A short and long-term strategy is presented in the full paper.

Predictable loss of experienced personnel in INR for the next 10 years, mainly by retirement, requires countermeasures from the point of view of KP. Obviously the harvesting of the tacit knowledge of the experts and converting it into a form that is available and useful should be the crucial point. INR should encourage software applications development and dissemination of them in all the departments. At the same time in the building up of a new and younger staff process we need to fight with the idea ‘ballast is discharged’, very present in the mind of the short term retiring experts. In this context our question is “what are the motivations for an expert to transfer his expertise before retirement?” In order to understand the actual INR KT state including the motivations for KT, a questionnaire-based investigation, involving the main part of experienced people (about 100 persons were investigated), was performed in January 2007. Some illustrative results are presented bellow.

The perception of the needed interval time for an optimal KT of the main part of the expertise is: between 1 and 3 years -30%, 4 to 6 years- 48%, 7 to 9 years 17%, more than 9 years- 3%. About 63% of the respondents intend to continue their present work after the retiring deadline: founding consulting companies- 9%; working with part-time contract for other companies-31%; working with part-time contract in INR activities- 52%; retiring postponement (with INR Scientific Committee annual approval) – 39%; working in universities – 21%. Each alternative introduces important financial advantages after retiring and is a real obstacle for KT before retiring. Therefore alternative methods are needed such as: continuous training of the “successors”; ‘Sempai-Kohai’ method [2]. Our strategy is based mainly on hiring young personnel with at least 3 years before the retiring of the existing one and using community of practice at interorgazational level. The intention is to obtain an optimal transfer of the tacit knowledge. Strong collaboration in educational programme for universities, such the e-learning project developed with Politechnica University of Bucharest allows us to obtain a more rapidly adapted graduates at INR research activities. Taking into account the limited funds we intend to obtain national funds as a partial support for the preparing of young graduate newcomers.

Our analysis includes the perception of the KT methods' effectiveness in INR. The following methods are studied: reports, procedures, user's manuals, computer codes, articles/papers, books, community of practice, mentoring, continuous training of the "successors", 'expert-newcomer tandem' method. Also, the barriers against knowledge sharing [3] perception for INR personnel are investigated such as lack of time, lack of trust,, the syndrome "knowledge is power", etc. The detailed results of the importance of each barrier on a 1 to 5 scale are presented in the full paper. Also the mechanisms that have effectively worked as KT in INR difficult period of '95-99 were studied, when a KM strategy didn't exist.

At the same time the importance of the following motivation increasing factors are measured: according retiring awards depending on the effective KT (I1); increasing of salary in the last years depending on KT (I2); clearance form completion only after relevant exit interview (I3); post-retiring collaboration contracts depending on number and quality of the prepared newcomers (I4); support for future publications (I5); free access at INR social/team building activities (I6). An illustrative matrix of the importance of the retiring experts' interests is presented in fig.1.

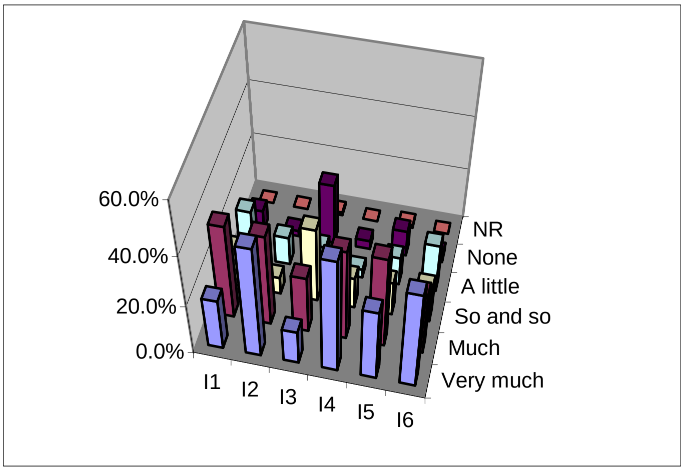

Fig.1 Matrix of interests- perception of the importance

Our results will contribute to a the redefinition of the long/short term INR strategy taking into accounts the INR and retiring experts interests.

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ROMANIAN KNOWLEDGE TRANSFER NETWORK IN NUCLEAR PHYSICS AND ENGINEERING- REFIN

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According to the requirements of the Romanian Nuclear Programme regarding the education and training of the skilled personnel for the nuclear facilities, a knowledge transfer network named REFIN (in Romanian: Retea Educationala in Fizica si Ingineria Nucleara) was developed since 2005. The knowledge target field is nuclear physics and engineering.

The Polytechnic University of Bucharest is the coordinator of this programme and other involved partners are University of Bucharest, University of Pitesti, University Babes Bolyai of Cluj-Napoca, University of Constanta, Institute for Nuclear Research Pitesti, Institute for Physics and Nuclear Engineering from Bucharest and the Training Center for Nuclear Units of Cernavoda NPP.

The main objective of this network is to develop an effective, flexible and modern educational system in the nuclear physics and engineering area that could meet the requirements of all the known types of nuclear facility and therewith be redundant with the perspectives of the European Research Area (FP7, EURATOM).

The first stage in this work was to gather information about the present status in the mentioned nuclear area in Romania, to assimilate and put this information in a data base on the program web-site (www.refin.pub.ro). In the following figure the home page of the REFIN web site is presented (in Romanian).

Based on this data base a global strategy was proposed in order to harmonize the curricula between the network faculties, to implement pilot modern teaching programs (courses/ modules), to introduce advanced learning methods (as Systematic Approach to Training, e-learning and distance-learning), to strengthen and better use of existing research infrastructure of the research institutes in network.

The second stage is the investigation of the training stage in other European countries related to the present status and the development trends of education in nuclear field. In the next future the English version will also be available and so REFIN will be easily accessed and used by the interested users. These facilities lead to REFIN improving and hereby it will become a network meeting the European requirements and synchronized with European countries systems.

The third step in the project development is creating the infrastructure for proposed strategy implementation. The education and training strategy is divided into several topics: university engineering, master, post-graduate, Ph.D. degree, post-doctor's degree, training for industry, improvement. For the first time in our country, this improved modular scheme will allow staff with different technical background to participate at different levels. In this respect, the European system with transferable credits (ECTS) will be used, which is already implemented in education, at university level, and it will be used in all activities related to training/education in nuclear field, with no respect to the training/education unit level. In that manner, one could establish a system that will allow the quantification/evaluation of each course level, as well as each training activity that a student attends, while allowing him or her to be involved, depending on specific professional requests, into a flexible educational scheme. This scheme will ensure competence enhancement and also the possibility of qualification development and a better mobility on the labor market. This activity is already in progress at the Institute for Nuclear Research (INR) Pitesti: students preparing the engineering diploma, Ph.D. students preparing the thesis, mixed (simulations and experiments) training stages for students, joined participations at nuclear meetings and conferences involving students, professors and INR specialists.

The main results of developing the excellence network might attract all interested organizations in the Romanian nuclear field (even during the project) and thereby will permit its expansion to other areas related with the nuclear field.

We consider that the construction of such a network is an important step in improving of both knowledge transfer process and collaboration between the responsible factors in the education and training of future specialists. Thus, we assume that the knowledge transfer is effective at any level: explicit, implicit and tacit, due to both the methods (mentoring, tutoring, e-learning, etc.) and a higher usage of the material base (documentation, experimental devices, models, etc.).

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MANAGEMENT OF NUCLEAR KNOWLEDGE ON AN INTERNATIONAL SCALE USING A SMALL UNIVERSITY RESEARCH REACTOR

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Abstract. The Atominstitut Vienna operates a 250 kW TRIGA Mark-II reactor since March 1962 used for nuclear education and training in the fields of neutron- and solid state physics, nuclear technology, reactor safety, radiochemistry, radiation protection, dosimetry, low temperature physics and fusion research. During the past 20 years about 640 students graduated with a diploma - or PhD degree from the Atominstitut attached to the University of Technology Vienna.

To perform nuclear relevant academic studies the Atominstitute offers about 100 highly specialised theoretical lectures and about 10 practical courses where students have to perform experiments in small groups of four on subjects mentioned above. Although the TRIGA reactor is a rather low power research reactor it is very easy and cheap to operate and an excellent tool to transfer knowledge and experience to the younger generation. This reactor is therefore not only used by other European universities such as University of Manchester or Bratislava Technical University but also by nuclear institutions such as the GRS/Germany, NPP Bohunice and NPP Mochovce for nuclear training.

On an international scale the Atominstitut co-operates closely with the nearby located IAEA in international research projects, coordinated research programs (CRP) and supplying expert services. Regular training courses are carried out for the IAEA for Safeguard Trainees, fellowship places are offered for scientists from developing countries and staff members carry out expert missions to research centres in Africa, Asia and South America. In the past 20 years more than 120 IAEA fellows from all over the world have been trained at the Atominstitut. The fellows spend between one to twelve month at the Atominstitut and are integrated in the respective work program. Experience showed that out of this fellowship a long-term relation between the institutes continues.

The paper focuses especially on the transfer of knowledge between generation on a national scale and also between a European research institute and overseas research centres on an international scale through exchange of experts and fellows.

Although Austria has a strong anti-nuclear policy nuclear knowledge has to be preserved as many neighbouring countries operate nuclear power plants, and discussions on international or bilateral level have to be carried out by educated experts in the nuclear field and not by emotions. Further the future of Austria’s power supply may require a revision of its anti-nuclear policy and therefore also long-term knowledge management is necessary. Finally nuclear knowledge is not only nuclear power but all areas of nuclear applications in industry, medicine and agriculture. The Atominstitut is presently one major contributor in preservation of knowledge in Austria.

SUMMARY OF THE FIRST MOROCCAN NUCLEAR POWER PLANT FEASIBILITY STUDY

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In the framework of the diversification policy of the energy primary sources and in compliance with governmental orientations, the Office National de l'Electricité (ONE), considers the nuclear power option as one of the technically viable solutions able to meet the future electrical energy requirements of Morocco It is in this framework that ONE in the early 1980s undertook site and technical-economic feasibility studies for the first Nuclear Power Plant (NPP) in Morocco in the context of an agreement signed with French company SOFRATOME, with the technical assistance of the International Atomic Energy Agency (IAEA). The site of Sidi Boulbra, located on the Atlantic coast between the cities of Safi and Essaouira, was selected and qualified as a site able to receive an NPP under the required nuclear safety conditions.

The said feasibility studies concluded that for reasons of insertion into the national grid, the nearest date for introduction of a first unit of 900-1000 MWe, in the framework of the equipment program focusing on the introduction of nuclear energy, would be somewhere near 2016-2017.

Currently, the reasons pointing to the importance for our country of going to nuclear energy are the following:

- Increase in the rate of dependency of external energy sources (96 % of primary energy sources are imported),
- The important growth of power demand (8 % each year)
- Uncertainty regarding future cost trends with regard to fossil fuel in an environment of soaring oil, coal and natural gas prices,
- Closure of the country's only coal mine (Jerada mine),
- Saturation of the hydroelectric potential to be equipped in Morocco,
- Negative environmental impact of projects using fossil fuel and the difficulty in finding international financing for such projects.

In light of these realities, ONE decided to:

- Update the feasibility study for the first NPP in Morocco in the framework of optimization of the development program of electrical generation equipment's between 2004 and 2020 to meet Morocco's energy needs.
- Provide the decision makers with elements allowing them to take decisions on the orientations and options regarding the implementation of the first a Moroccan NPP and, in parallel, giving the necessary confident to the public, so as to have greater visibility with regard to the introduction of this energy source in the electrical system of the Kingdom, and to assess the relevant suitability and it's positive environmental impact.

Indeed, one of the main issues taken into consideration in the Sidi Boulbra NPP project, the public information policy or guidance's to be implemented in this important project, is of greater importance due to the negative effect of nuclear energy perception after the major nuclear accident of Tchernobyl.

A big work is now ongoing and remains to be done in order to reduce the public worries and to show him the main advantages of setting up a NPP project.

This aspect is tightly linked with the establishment of a set of national nuclear regulations and also international agreements or conventions that have been signed by our country and which are now accompanying nuclear activities.

On the other hand, it should be noted that Morocco has a modest experience with regard to nuclear knowledge management related to these aspects in the framework of realization of the first nuclear research center of Maamora based on TRIGA 2 research reactor which is presently in commissioning phase.

In this paper, we shall present the elements of public information program including the main socioeconomic, technical, legal and environmental arguments and propose an action plan to carry out this program.