UNDERSTANDING THE KNOWLEDGE MANAGEMENT LINK TO ORGANIZATIONAL PERFORMANCE IN NUCLEAR POWER PLANTS

Effective knowledge management (KM) enhances a firm’s capability to assimilate, create and exploit knowledge. It is an important enabler of long-term organizational performance and is particularly important in technology intensive industries such as nuclear power. This paper summarizes preliminary research exploring the link between KM practices and nuclear power plant (NPP) organizational performance based on a review of the literature and meetings with managers during several plant site visits. It proposes a research model, hypotheses and a methodology for a planned further and more detailed empirical study.

Introduction

NPPs have been doing KM-related activities for a long time without explicitly recognizing them as such. There are many examples of this such as equipment reliability programs, systematic approach to training, configuration management of design basis information, documented operational procedures, plant work management systems, outage planning systems, pre-job briefing practices, document management systems, etc. (IAEA, 2006). However, only recently has the industry begun to recognize that there are significant strategic benefits to managing knowledge and knowledge processes on a corporate-wide level as part of a KM program (IAEA, 2006).

A recent report (IAEA, 2006c) summarizes key reasons cited at a recent (2004) international conference on KM in the nuclear industry as to why KM is an emerging priority. The nuclear industry is a maturing industry where recent high attrition rates have highlighted the vulnerability of NPPs to the loss of tacit knowledge. Pro-active measures aimed at knowledge retention have been needed. There is concern in the industry over the “pipeline” of new and adequately skilled graduates to replace retiring NPP knowledge-workers. This is due to the lack of university level programs targeting specific nuclear engineering and science skills. There is also recognition that it takes many years of on-the-job training to build the competencies and expertise needed for many NPP staff roles. Compounding the problem is the fact that the aging fleet of nuclear plants will need either refurbishment or decommissioning in the near future, and this comes at the same time that many new plant construction projects are being planned and launched. This is creating high demand for specialized nuclear skills. Finally, the report states there is also a strong pressure to achieve higher levels of productivity in NPPs, and this is driven by factors such as deregulation and competition, rising operating costs, and opportunity from use of technology.

In general, NPP site organizations have been found to share common organizational characteristics in that almost all plants have similar basic organizational elements: operations,
maintenance, technical support, administration, human resources, training, nuclear oversight and regulator affairs, supply and procurement, planning and work management (EPRI, 2006; IAEA, 2001; NEI, 2003). NPPs are technology intensive organizations that require a high level of industry and plant (design) specific knowledge to be maintained and operated safely (IAEA, 2006). Organizational efficiency, safety, and operational performance vary between plants (IAEA, 1999). This paper summarizes preliminary research into the link between KM practices and NPP organizational performance and presents a model and hypotheses for further research.

Although a fair body of academic literature exists describing research on the subject of specific KM practices and their impact on performance in organizations (e.g. Feng et al., 2004-5; Davenport and Prusak, 1998; Chang and Ahn, 2005; Nonaka and Takeuchi, 1995; Chen and Mohamed, 2007), very few empirical studies (e.g. Pham and Swierczek, 2006; Liu & Tsai, 2007; Feng et al., 2004-2005) have explored the relationship (Keskin, 2005; Lee et al., 2005; Liu and Tsai, 2007). Liu and Tsai (2007) used balanced scorecard measures on a study of 560 high tech Taiwan companies and reported performance improvements in the range of 5-10% on financial, customer, and internal business process measures, and between 10-15% improvement when measured against learning and growth measures. Feng et al. (2004-2005), in an empirical pair-wise controlled study of “KM system adopter firms” found significant performance improvements in firms within two years of implementing a KM system, when performance was measured against administrative costs, productivity metrics, and financial performance data. In general however, the issue has not been extensively researched and the mechanisms by which KM practices affect organizational performance are not well established or understood. Further, little empirical research has been done on this topic in the specific context of NPP operations (IAEA, 2006; EPRI, 2006; Lowthert, 1996). Another factor found to influence the effectiveness of KM initiatives in improving NPP performance is organizational culture (Ribiere, 2001; Yeung et al., 1999). By gaining insights 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 help maximize the benefit from KM to achieve and maintain improvements in plant performance.

Fundamentals of Knowledge Management

Before embarking on a discussion about KM and its role in achieving organizational performance, it is important to define what is meant by the terms “knowledge”, “knowledge management”, and “performance”. There are numerous definitions of “knowledge” in the literature. There appears to be general agreement that knowledge is “information that is contextual, relevant and actionable” (Soliman and Youssef, 2003). There are also different classifications found in the literature of the types of knowledge: knowledge can be viewed as a resource or a process (Assudani, 2005), it can be considered at the individual, group or organization level (Hedlund, 1994), it is often distinguished as either tacit (i.e. experiential) or explicit (codified) knowledge (Nonaka and Takeuchi, 1995), it can be categorized as factual, conceptual, procedural, or even meta-cognitive (i.e. knowledge about knowledge) (Anderson et al., 1998). Szulanski (1996) defined knowledge as “…what the firm knows in terms of best practices”. Davenport and Prusak (1998) define it as “…a mix of experience, values, contextual information, and expert insight”.

The literature generally agrees on the many characteristics of knowledge: knowledge is contextual, it can be re-used (Allee, 1997), its benefits are obtained only if it is applied (Davenport and Prusak, 1998), its value may change over time (Davenport and Prusak, 1998), it often has to be renewed or maintained (Dixon, 1999), it can be difficult to transfer, capture, distribute (Sveiby, 1997), it is developed through learning processes (Nonaka and Takeuchi, 1995), its acquisition depends on memory, past experience, expertise, knowledge transfer mechanisms, opportunities for learning (O’Dell et al., 1999), it facilitates effectiveness in problem solving and decision making (Davenport and Prusak, 1998),
it enables “sense-making” abilities (Brooking et al., 1998), it enables higher learning of complex concepts and deep insights (i.e. it has accumulative benefits) (Soliman and Youssef, 2003), and finally, its creation and utilization can be enhanced with technology (Gallivan et al., 2003).

The literature on organizational learning (which overlaps with literature on knowledge management) provides useful insights. It helps clarify and establish the importance of knowledge processes in organizational learning and the role organizational learning subsequently plays in improving organizational performance and building competitive advantage (Huber, 1999). In general, the literature agrees that the accumulation and use of knowledge in organizations is enabled by effective knowledge processes (Gallivan et al., 2003). Various authors use different terms and definitions to describe knowledge processes, however, they can be summarized as five basic constructs (Chang and Ahn, 2005): knowledge acquisition, transfer, creation, retention, and utilization. For the purposes of this research, the following definitions of these five basic knowledge processes have been adopted:

- **knowledge acquisition** (e.g. as used by Aramburu, 2006) is the process of obtaining and introducing new external knowledge (whether tacit or explicit) into the organization, and includes knowledge identification or selection processes for acquisition.
- **knowledge transfer** (e.g. as used by Meckler, 2001) is the exchange of knowledge within the organization (directly or indirectly) and includes knowledge sharing or distribution.
- **knowledge creation** (e.g. as used by Heinrichs, 2001, or Foss et al., 2006) is the generation of new knowledge or knowledge development, and may also include knowledge identification and selection processes when associated with internal knowledge generation.
- **knowledge retention** (e.g. as defined by Young, 2006) is the process of keeping knowledge (whether tacit or explicit) within the organization and maintaining its availability. It incorporates the related concepts of knowledge capture, preservation, storage, retrieval, accessibility, identification and protection in the context of knowledge retention.
- **knowledge utilization** (e.g. as defined by Koskinen, 2003) is the process of knowledge application or use.

Numerous definitions of knowledge management exist in the literature. Newman (2003) defines KM as “…the processes that govern the creation, dissemination, and utilization of knowledge”. O’Leary (1998) defines KM as “…managing the organization’s knowledge by creating, structuring, disseminating and applying it to enhance organizational performance”. Alavi and Leidner (1999) define KM as “…the process to acquire, organize, and communicate knowledge of employees so others may be more effective in their work”. Andriessen (2004) argued that KM is “…organizing and optimizing knowledge processes”. For the purposes of this research the definition that is felt to be most appropriate is that “KM is the set of processes that seeks to change the organization’s present pattern of knowledge processing to enhance both it and its knowledge outcomes” (Firestone & McElroy, 2004). This definition clearly recognizes the KM is the set of practices (activities or initiatives or programs) under management control that can influence the quality of knowledge processes in the organization.

KM literature has developed by drawing upon the theory and principles from many management schools of thought including: information theory, business process re-engineering, quality management, human resource management, intellectual capital theory and organizational learning theory. It has also been argued by various authors that KM is a key element of an effective integrated management system (IAEA, 2006c). As a subject of research, KM covers a wide domain, offers many varied (and inter-
related) issues, can be a challenge for those new to the subject, and is often poorly understood. The objectives of KM can be described as promoting and enabling the building, maintenance, and utilization of knowledge through effective knowledge processes (both tacit and explicit) within the firm, with the purpose of making knowledge workers more effective and to promote continuous improvement and innovation (APQC, 2000). KM aims to reduce the cost of being effective and increase the pace of learning and innovation. It often includes targeted initiatives such as preserving existing knowledge, reducing the loss of intellectual capital (IC) from employees who leave, increasing collaboration and enhancing knowledge sharing, improving the skill level of employees, and increasing the productivity of workers by making knowledge accessible to employees. KM practices are intended to enhance an organization’s capacity for effective action. Increased organizational learning and knowledge utilization helps staff do the right things, to do them right, and the first time.

Many authors (IAEA, 2006b; Arora, 2002; Young, 2006; Chang and Ahn, 2005; Treasury Board of Canada Secretariat, 2002; Gallivan et al., 2003; Haugh et al., 2004; and Starns and Odom, 2006) maintain that in order for KM to be effective, it must be implemented in a coordinated company-wide fashion as a system, and within the context of clear strategy and goals. In a most general sense, the literature agrees that when KM is viewed and managed strategically in this manner, it can be referred to as a Knowledge Management System (KMS). This also implies measures are developed and there is feedback and assessment for continuous improvement. However, there are many differing perspectives in the literature as to what a KMS is and how it should be implemented. Examples include KMS as:

- an integrated component of the quality management system (QMS), which incorporates quality of knowledge-based processes (e.g. Carlin et al., 2007, or the Malcolm Baldrige Award as described in Smith, 2008);
- an component of an integrated management system (IMS) (IAEA , 2006);
- a process-oriented knowledge management (POKM) approach (Maier and Remus, 2002); or
- an organizational memory system (OMS), which is essentially a set of repositories of information and knowledge that the organization has acquired and retains (Huber, 1999).

There is merit in all of these perspectives and it can be argued than no single view is entirely correct. An effective KMS may incorporate aspects of each of them. However, it is clear many authors (Corso et al., 2003; Chen Liu, 2003; Edwards et al., 2005; Feng et al., 2004; Gallivan, 2003; Haugh et al., 2004) agree that if a collective set of management practices across an organization are aimed at improving knowledge processes and are planned and coordinated in a strategic manner to address that organization’s business needs, then these KM practices will have maximum benefit. Few authors agree on what best practices are needed to achieve effective KM. A wide range of KM initiatives have been observed in NPPs, and these range from strategy and policy, to human resource practices, to technology support, to organizational culture, to organizational processes and performance management practices (IAEA, 2006). Intuitively, it is clear that KM has a role to play in organizational performance. Numerous definitions of performance can be found in the literature, however there is general agreement that performance is “the level to which a goal is attained” (Dwight, 1995), and thus it is argued that KM practices help firms achieve their goals.

**Impact of Knowledge Management in the Organizational Context**

In terms of organizational workflow and task execution, a KM perspective helps organizations to understand the knowledge processes and knowledge requirements of everyday tasks in a given work environment. A KM perspective gives organizations a new “lens” through which to view all aspects of the organization’s work processes. For example, a work activity can be examined in terms of: the
expertise (or competencies) needed to perform the task; the various participants (and their interactions) in performing the task; the information needs, flows, products, and inter-dependencies on the various players in the activity; and the work procedures, methodologies, and decision processes involved (adapted from Newman, 2003). Figure 1 illustrates this. Taking a KM perspective on any work activity implies considering the knowledge processes associated with it. This gives rise to many questions that help to understand the knowledge and knowledge process dependencies associated with a task such as: what are the critical knowledge processes involved; what are the characteristics of the relevant knowledge needed; who has or should have this knowledge; what mechanisms are needed for the generation and utilization of this knowledge; and what organizational conditions, processes, and changes are needed to make the work efficient and effective (e.g. organizational structure, incentives, training, procedures, data, technology support, or culture etc.).

Figure 1

Understanding Work Activity from the KM Perspective

Nonaka and Takeuchi (1995) provide useful insight into knowledge transfer processes and strategies. Figure 2 highlights how knowledge can be transferred between individuals (tacit to tacit), between individuals and codified form (tacit to explicit), and vice-versa through processes they refer to as socialization, externalization, combination, and internalization. Many other authors present similar concepts, and these models aid in developing an understanding of the firm and its business processes in terms of knowledge processes and process requirements. The net effect of high quality knowledge processes (i.e. knowledge acquisition, transfer, creation, retention, and utilization) is organizational learning, both at an individual and collective level, and in both tacit and explicit domains (Firestone and McElroy, 2004).

Many authors (e.g. Young, 2006; Chang and Ahn, 2005; and Gallivan, 2003) describe how data is assimilated into information, information into knowledge, and ultimately knowledge into wisdom. The process also acts in reverse, as wisdom guides the application of knowledge, knowledge helps to interpret, filter, and make sense of information, and likewise information helps us to assimilate raw data and put it in context. Thus an organization builds and maintains its organizational knowledge base in this manner and in turn ensures its capacity for effective decision making and action (Firestone and McElroy, 2004). This knowledge base can be viewed as the sum total of tacit knowledge (skills, experience base and expertise that contributes to the competencies of the organization’s work-force) and the explicit knowledge that is captured and represented in artefacts and archives (such as databases, information systems, documents, procedures, manuals, records, etc.). Continuous learning processes are needed to maintain an organization’s knowledge base, and this is a fundamental objective of KM (O’Leary, 1998).
KM in the NPP context presents many 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 an operations and management perspective); lengthy technology and plant life-cycles; highly capital-intensive plant assets (and thus the need for risk-informed asset management decisions); a reliance on multi-disciplinary technologies and expertise; competing operational objectives (i.e. 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 effective knowledge processes in an organization that is a complex socio-technical system. On top of all this, stringent requirements for safety, environmental and equipment qualification, nuclear quality assurance, nuclear security and safeguards, and design configuration management must be met, all in the context of a regulated industry environment.

Thus NPPs are very knowledge intensive and knowledge driven organizations. Wigg (1997) provides a useful model to help understand this (see Figure 3). Intelligent-acting “knowledge workers” go about their work routines in all areas of the organization (operations, maintenance, training, etc.). Learning and continuous improvement occurs through experience gained and lessons learned. Throughout the course of carrying out work activities, structural knowledge assets are created, and these may take many forms (e.g. internal products and services, information systems, operating and management practices, organizational roles and responsibilities and structure are defined, in-house technology may be developed and applied, explicit knowledge bases are created such as documentation or archives, and training programs are developed). Learning and innovation occurs on a continuous basis, and this enables effective utilization and improvement of the structural knowledge assets. This occurs within an organizational culture and factors such as empowerment and authority structures (that enable or permit action), incentives and rewards (that provide motivation), opportunities to acquire knowledge, and capabilities and capacity for problem solving contribute to a pro-active knowledge driven organization.
The challenge of achieving sustained high level of operational performance in today’s NPPs can be described as a problem of optimizing human behaviour and action in a complex socio-technical work environment, within a framework of operating constraints, to achieve the simultaneous optimization of many goals, and according to a large array of business and work processes (IAEA, 1999). Nuclear plant organizations are heavily knowledge-dependent and their operational needs demand a high level of knowledge-based infrastructure in the form of human capital, underlying technology (of the plant), and work methodology (IAEA, 2006b). It is clear the terms “knowledge-worker” and “knowledge organization” are all the more relevant in the multi-disciplinary work environs of nuclear plant organizations. For these reasons, NPP managers are interested in understanding and influencing the factors that affect the building and retention of the corporate knowledge base and its effective utilization. KM then comes to the fore as a set of practices by which management may influence the quality of knowledge processes (i.e. knowledge acquisition, transfer, creation, retention, and utilization) to this end.

There is agreement in the literature that to implement KM effectively in an organization, a strategic approach is required (Hedlund, 1994; Hitt and Ireland, 1995). A key success factor is seen to be the ‘fit’ (i.e. alignment) between people (and their competencies), procedures and processes (i.e. management controls, work practices, methods, business processes etc.), information technology infrastructure (i.e. information systems/technology), and plant and equipment (i.e. the physical plant technology base), and collectively with the organizational learning culture (IAEA, 2006b). In NPPs, this alignment is seen to be particularly important due to the complex technical work environment, interdisciplinary knowledge requirements, and the need to work to well-defined processes and procedures (IAEA, 2006b). See Figure 4.
The Role of IT Infrastructure

An IT infrastructure is seen as key to enabling and supporting effective knowledge processes, and as a necessary element in optimizing a corporate-wide KM System in NPPs (EPRI, 2006). Most NPP organizations see the IT infrastructure as a way to cost reduction. The importance of IT systems and tools is due to several factors: they permit a means of data/information management or conversion (e.g. data capture, transfer, organization, storage, and archival or retrieval) (Edwards et al., 2005); they provide interpreted or interpretable information (Corso et al., 2003); they aid in knowledge generation (i.e. capture and learning, innovation) (Alavi and Leidner, 2001); they can provide a means to identify plant system patterns and behaviours (EPRI, 2006); they can (in the case of decision support systems or “DSSs”) capture tacit knowledge in the form of “decision logic or criteria” (Gallivan et al., 2003); they can be useful support tools for capturing, presenting, or tracking processes, procedures, and work task execution (Feng et al., 2004-5); and finally, they can help maintain and make available the various data and information on the large volume of rules, constraints, sequences, guidelines, limits and conditions needed for safe and reliable plant operation (Haugh et al., 2004). IT also offers the ability to integrate data and information from several sources. It can be argued that these systems provide an extension of human capability for learning (acquiring and processing data, information), communication (exchanging data and information), memory (retaining data and information), organizing data into information (filtering, storing), and interpreting (visualization and analysis). These properties enable more effective use of tacit knowledge by improving the availability of contextual data and information. This adds meaning by aiding in knowledge building and sense making. It facilitates overall comprehension by providing opportunity to create and utilize knowledge by combining and synthesizing existing tacit and new contextual explicit knowledge. Clearly, it can be argued IT infrastructure also aids firms in achieving their goals.
Research Model and Hypothesis: Exploring the Link Between KM and Performance

Although the findings from the literature support the notion of a link between KM practices and organizational performance, the question remains as to the nature and strength of this relationship, and whether it can be established with empirical evidence. Further research is underway to address these issues. The approach being taken is an empirical study of NPPs using a survey questionnaire, developed to measure the following constructs: the extent of KM practices in each organization (independent variable), the effectiveness of technology support (independent variable), the effectiveness of knowledge processes (intervening variable), and organizational performance (dependent variable). Figure 5 illustrates the author’s proposed theoretical model (i.e. the Knowledge Management Performance Model).

Figure 5

The Proposed Knowledge Management Performance Model (KMPM)

A key assumption of the model is that in knowledge-driven NPP organizations, productive and effective decision and work processes will result in increased organizational performance on many dimensions. The most basic hypothesis of this research is that increased performance will occur when the organization has high quality knowledge processes. This means that knowledge processes (i.e. acquisition, transfer, creation, retention, and utilization) have to be aligned and optimized to meet the knowledge requirements of the business processes. This builds on the research of Firestone and McElroy (2004) who describe the link between KM and performance as follows:

Organizational performance is determined by the quality of actions taken by employees in the performance of work, which is determined by the quality of decisions made related to these actions, which is determined by the quality of decision-making, which is related to the quality of knowledge utilized in the context of each decision, which is related to the quality of knowledge processes in the firm, which is influenced by the quality of KM.
The literature provides some useful insights into the role and influence knowledge management in organizations have with respect to knowledge processes and organizational learning. Technology support has also been established in the literature as an important contributor. Although the literature provides useful insights into their collective effects on organizational effectiveness and operational performance, little or no empirical research has been done to specifically examine and explain these relationships. The questions pursued by this research are:

- To what extent does KM in NPP organizations impact organizational performance, and by what mechanisms does this occur?
- To what extent is KM currently in use in operating NPPs?
- To what extent does KM impact knowledge processes?
- To what extent does technology support impact knowledge processes?
- To what extent do knowledge processes impact organizational performance?

The answers to these questions are of great interest to NPP owners and operators. Little if any qualitative management research has been done on this topic (IAEA, 2006; EPRI, 2006; Lowthert, 1996), likely due to the inaccessible nature of NPP organizations. No prior empirical research addressing this research topic was found. In order to probe into these research questions, the proposed theoretical model (Figure 5) of the impact of KM practices on NPP performance is grounded in existing theory and adapted to the NPP organizational environment. The following hypotheses are derived from it:

- Higher levels of KM practice will positively influence knowledge processes.
- Higher levels of KM practice will positively influence organizational performance through more effective knowledge processes.
- Higher levels of technology support will positively influence knowledge processes.
- Higher levels of technology support will positively influence organizational performance through more effective knowledge processes.
- More effective knowledge processes will positively influence organizational performance.

The Research Methodology

This research involves a two-step approach. First, preliminary research has already been conducted as a participant in several NPP workshops and site visit meetings on the topic KM. A formal literature review has also been completed, a brief summary of which is provided herein. Based on the findings of this preliminary research, a formal survey instrument (using mostly qualitative perception measures) has been developed and will be administered to the global community of NPP site organizations. Survey methodology was chosen in this study as the preferred data collection approach due to its versatility and general acceptance as a practical and proven technique for measuring perceptions of organizational learning (McGee and Prusak, 1993). The survey will employ Likert-type scales on the grounds that the technique is well established in social sciences research and has been used in many empirical management studies including studies specific to the measurement of management perceptions of knowledge processes (e.g. Hitt and Ireland, 1997, Malhotra, 1997).
The unit of analysis is an operating NPP station organization or “plant site operation”, whether a single or multi-unit station. The intended sampling frame is the entire global population of NPPs. This population is well defined and finite (estimated at between 180 and 200 site organizations). The survey instrument is intended to be completed by the most senior operations manager at each station (i.e. the sampling element will be an individual, and depending on the organization, this person may be identified as the Chief Nuclear Officer, Plant manager, Vice-President of Operations, Station Technical Manager, Director of Operations and Maintenance, or person in similar most senior position) who has a solid understanding of organizational practices and operational performance, and who can solicit input from various departments or subordinates as needed to complete particular questions.

In order to investigate the impact of KM practices on NPP organizational performance, this study will use statistical methods for testing the hypotheses based on standard multivariate regression. To confirm the statistical assumptions of the analysis, checks will be performed to confirm the four important statistical assumptions (Hair et. al., 2006): normality, homoscedasticity, linearity, and absence of correlated errors. Reliability will be achieved by using well-established constructs from the literature and the use of (or slight adaptation of) proven measures.

NPP organizational performance has been operationalized as two distinct constructs: organizational effectiveness (using existing measures adapted from IAEA, 1999; INPO, 2007; and NEI 2003) and operational performance measures defined by WANO (2005). WANO started tracking NPP performance in 1991 based on a set of simple but key quantitative overall plant performance indicators, each a measure of operational “efficiency”. It is now recognized that the WANO performance indicators provide an excellent measure of how well an NPP is managed overall (WANO, 2005). WANO claims that as of 2005 reporting year, 97% of operating NPPs reported on their indicators. As these indicators are widely accepted and reported as meaningful, simple, clear, and easy to derive, they have been chosen for use in this study. The WANO indicators used are:

- **Unit Capability Factor** (the percentage of maximum energy generation that a plant is capable of supplying to the electrical grid, limited only by factors within control of plant management.)
- **Unplanned Capability Loss Factor** (the percentage of maximum energy generation that a plant is not capable of supplying to the electrical grid because of unplanned energy losses, such as unplanned shutdowns or outage extensions. A low value indicates important plant equipment is well maintained and reliably operated and there are few outage extensions.)
- **Forced Loss Rate** (is the percentage of energy generation during non-outage periods that a plant is not capable of supplying to the electrical grid because of unplanned energy losses, such as unplanned shutdown or load reductions. A low value indicates important plant equipment is well maintained and reliably operated.)
- **Collective Radiation Exposure** (the effectiveness of personnel radiation exposure controls for boiling water reactors (BWRs), pressurized water reactors (PWRs), pressurized heavy water reactors (PHWRs), light-water cooled graphite reactors (LWCGRs), and gas-cooled reactors (GCRs). Low exposure indicates strong management attention to radiological protections. Measured in Man-Sieverts per unit, Man-rem per unit).
- **Unplanned Automatic Scrams per 7,000 Hours Critical** (the mean scram (i.e. automatic shutdown) rate for approximately one year (i.e. 7000 hours) of operation. Unplanned automatic scrams result in thermal and hydraulic transients that affect plant systems.)
- **Industrial Safety Accident Rate** (the number of accidents that result in lost work time, restricted work, or fatalities per 200,000 work-hours).
• **Safety System Performance** (the safety system performance indicator monitors the availability of three important standby safety systems at each plant. Safety systems that are maintained in a high state of readiness have a high probability of being capable of mitigating off-normal events.)

• **Fuel Reliability** (the fuel reliability indicator monitors progress in preventing defects in the metal cladding that surrounds fuel. Maintenance of fuel cladding integrity reduces radiological impact on plant operations and maintenance activities.)

• **Chemistry Performance** (the chemistry performance indicator provides an indication of progress in controlling chemical parameters to retard deterioration of key plant materials and components. These parameters are already being maintained within strict guidance developed by the industry.)

A pre-test of the survey has been conducted on a small but representative sample (12 NPPs) of the target population of NPP organizations. As the population size is known (~440 operating NPPs), the sampling error can be reduced by using the “finite population correction factor” (Jobson, 1999). The survey instrument was also peer reviewed by several academics and nuclear industry managers.

### Findings of Preliminary Research and Conclusions

As a part of this research, the author has participated in over ten different IAEA-sponsored meetings on the specific topic of “KM in NPPs” with nuclear industry managers (some during NPP site visits, others as IAEA industry workshops). These meeting forums have provided useful insights and a better understanding of the types of KM practices employed at NPPs. Table 1 (see Appendix) summarizes the KM practices found to be currently in use at NPP sites visited. The preliminary (informal) research findings to date indicate that successful and sustained superior life-cycle operation of an NPP is believed (by NPP managers) to be directly dependent on the quality and effective utilization of the organization’s knowledge base. Almost all NPP managers asked (over 100) agreed that NPP organizational effectiveness is very much dependant on the strength of the organization’s knowledge base and its utilization, and that this is in turn is dependent on how closely knowledge processes were aligned with and supported the business requirements of the organization. From the literature review, it is clear that KM practices are intended to achieve exactly this objective. These preliminary findings were useful to interpret the literature in the NPP organizational context and to confirm and refine the theory and hypotheses of the research.

In summary, KM is seen as an important strategic issue for NPPs. Achieving effective KM is perceived as difficult and challenging. KM practices are recognized in the literature as important enablers of superior organizational performance. Information technology infrastructure is also seen as playing an important role in enhancing knowledge process effectiveness and supporting the achievement of higher organizational learning. Both the extent of KM practices and the effectiveness of technology support are hypothesized to contribute to successful and sustained superior operational NPP performance through two intervening variables: effective knowledge processes and organizational effectiveness. Preliminary research findings to date support this hypothesis. By empirical study, this ongoing research will investigate whether NPP organizations with higher levels of KM practice achieve higher levels of organizational effectiveness and operational performance. Further findings from this research will be published once the survey data has been collected, analyzed, and interpreted.
Appendix

Table 1 summarizes the various KM practices currently used by industry managers. This list summarizes the range of activities identified by NPP managers during a number of IAEA-sponsored meetings and workshops on NPP KM that the author has participated in as part of this research.

Table 1

- Company-wide KM System
- Wikis (i.e., a collaborative repository)
- Communities of Practice
- Computer based training (CBT)
- Training Simulators
- Elicitation Interviews
- Documentation (codification) Initiatives
- Mentoring and Coaching
- Information Management
- Document Management
- Peer NPP Assist Visits
- Experience Reviews
- Story Telling
- Data Mining and Full-Text Searching
- Cross-Functional Teams, Team Learning
- Knowledge Loss Risk Assessments
- Intranet Portals
- Enterprise Application Software
- IS/IT Infrastructure
- Concept Maps, Knowledge Maps
- Intellectual Asset Management
- Promoting a Knowledge Sharing Culture
- Online Resource Locators
- KM Benchmarking or Self-Assessment
- Workforce or Succession Plans
- Leadership Development
- Use of Retired or Retiring Specialists
- New Staff Training Strategies
- Directed Recruitment
- Graduate Pipeline Development
- Formal Training, Employee Development
- Operational Feedback
- Experience Learning Systems
- Process-oriented KM
- Decision Support Systems
- Knowledge Audits
- Enterprise/Nuclear Asset Management
- Design Basis Information Management
- Risk-informed Decision Processes
• Human Performance Improvement Programs
• External Knowledge Adoption

References


