TOPIC:

Linking Knowledge Management Practices to Nuclear Power Plant Organizational Performance

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Abstract

Knowledge management (KM) 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 theory 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 benefits obtained vary from station to station. This paper provides insights from research being done at Atomic Energy Canada Ltd. to explore the link between KM and NPP organizational performance and summarizes findings from a review of the literature and several station visits.

1. Introduction

Before embarking on a discussion about KM and its links to performance, it is important to define what the terms “knowledge”, “knowledge management”, and “performance” mean. 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 or explicit knowledge (Nonaka and Takeuchi, 1995); and it can be categorized as factual, conceptual, procedural, or even meta-cognitive (i.e. knowledge about knowledge, as per 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’. This paper considers knowledge in the context of its utilization to perform organizational work and considers knowledge as the ‘capacity for effective action’.

The literature generally agrees on the many characteristics of knowledge: knowledge is contextual; it can be re-used; its benefits are obtained only if it is applied; its value may change over time; it has to be renewed or maintained; it can be difficult to capture, transfer, and distribute; it is developed through learning processes; its acquisition depends on memory, past experience, expertise, knowledge transfer mechanisms, and opportunities for learning; it facilitates our effectiveness in problem solving and decision

making; it enhances our "sense-making" abilities; it enables higher learning of complex concepts and the realization and synthesis of deep insights (i.e. it has accumulative benefits); and finally, its creation and utilization is enhanced with technology.
Various definitions of "knowledge management" also exist in the literature, however most are consistent with the notion that it is a coordinated approach taken to managing the organization's knowledge to improve organizational performance, and it is achieved through knowledge creation, structuring, and dissemination processes (O'Leary, 1998). Newman (1992) defines KM as '…the processes that govern the creation, dissemination, and utilization of knowledge'. 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'. For the purposes of this research, the definition put forward by Andriessen (2004) that KM is '…organizing and optimizing K-processes', is felt to be most appropriate. Knowledge management processes are defined in many ways by different authors using various analogous terms. Hedlund (1994) describes KM processes as: knowledge capture and storage; transfer and sharing; transformation; creation or generation; and representation.

Intuitively, it is clear that KM has a role to play in organizational performance. Numerous definitions of performance can be found in the literature, with some agreement that performance is 'the level to which a goal is attained' (Dwight, 1995). Performance assessment is widely discussed and has many definitions in the literature. Is has been defined as 'the acquisition and analysis of information about the actual attainment of company objectives and plans, and about factors that may influence this attainment' (Kerssens-van Drongelen and Cook, 1997); as "the process of determining how successful organizations or individuals have been in attaining their objectives" (Sinclar and Zairi, 1995); and as '…assessing the level to which a goal is attained' (Dwight,1995). Typical Measures of organizational performance include: productivity (output), efficiency (output/input), effectiveness (utility, benefit), quality, safety, reliability, cost. Further, the focus of these measures may be at an individual, team or unit, or organizational level. The focus of performance assessment can also be on people, processes, or systems (including support systems).

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. 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 are thought to be significant, such as the extent to which KM practices are aligned with and support operational best practices. Further examples, such as life-cycle equipment maintenance or the configuration management of plant design basis information (both of which are knowledge-driven processes), have a direct impact on safety and production. Finally, the extent of adoption and maturity of KM practices in a NPP may be a key factor.

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. Section 2 provides some background information and context on basic KM ideas and principles. Section 3 highlights findings on KM in the NPP context. Section 4 summarizes findings from the literature and from several NPP site visits regarding how KM plays an important role in organizational performance. Finally, Section 5 summarizes the research findings to date.

2. Background and Basic Knowledge Management Principles

KM is an integrative management theory and borrows elements from the theory and principles of many other management "schools of thought" including: information systems theory and information theory, business process re-engineering, quality management, organizational behaviour, systems engineering, human resource management, intellectual capital and asset theory, innovation management, communications theory, organizational learning theory, human psychology and cognitive process theory, and even transaction cost theory. It can also be argued the KM is complementary to (and perhaps a key element of) integrated management systems and corporate governance approaches. Thus, as a subject of research, KM topics are of a wide domain and have many varied (and often inter-related) aspects, can be somewhat challenging, and are easily miss-understood, and perhaps often miss-applied.

The objective of KM then could be summarized as: to promote and enable the building and maintenance of knowledge and knowledge processes (both tacit and explicit) within the firm, with the objective of making knowledge workers more effective and efficient, and to acquire and create new knowledge to promote continuous improvement and innovation. KM aims to reduce the cost of being effective and increase the pace of innovation. This includes initiatives such as preserving existing knowledge, reducing the loss of intellectual capital (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. KM enables a pro-active culture in which increased knowledge helps staff do the right things, and do them right.

From an organizational workflow and functional work breakdown perspective, KM concepts can be applied to everyday tasks in a firm's work environment. The KM viewpoint gives organizations a new "lens" through which to examine all aspects of the organizations work processes. For example, any given work activity can be thought of in terms of the expertise (or competencies) needed to perform the task, the various participants in the task and the roles they play and interactions, the information needs, flows, products, and inter-dependencies on the various players in the activity, and the work procedures, methodologies, and decision processes involved (see Figure 1).

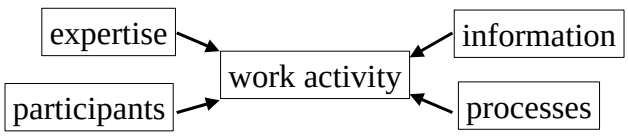

Figure 1: Viewing Work Activity from the KM Perspective

This type of thinking gives rise to many questions that help to understand the knowledge and knowledge process dependencies associated with the 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, what organizational conditions, processes, and changes are needed to make the work efficient and effective (e.g. organizational structure, incentives, culture etc.).

Nonaka and Takeuchi (1995) provide useful insight into knowledge transfer processes and strategies. Figure 2 highlights how knowledge can be transformed and transferred between individuals (e.g. tacit to tacit), between individuals and codified form (e.g. tacit to explicit), and vice-versa through processes they refer to as socialization, externalization, combination, and internalization. Many other authors present similar concepts, and this and other models aid in developing an understanding of the firm and its work processes in terms of knowledge processes.

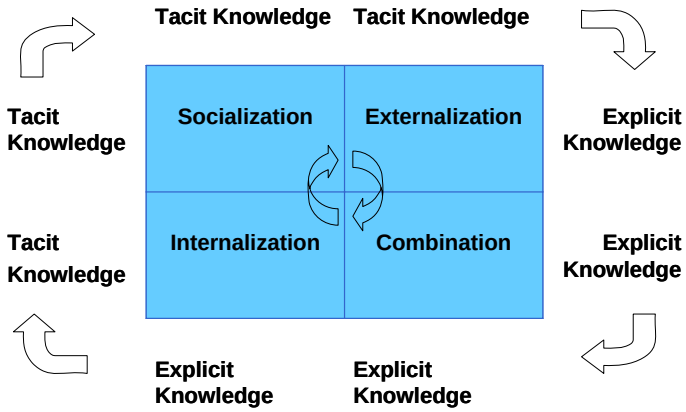

Figure 2: Knowledge Transfer Process Strategies (Nonaka and Takeuchi, 1994)

To ground this theory in some practical examples, knowledge transfer processes can be found in many typical organizational initiatives such as: the use of Intranets for online access to documents, manuals, or procedures; the implementation of a new enterprise application software (EAS) system; programs to manage the loss of key skills due to attrition; or the codification of safety, quality, work procedures, or training material. The net effect of knowledge processes is that 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. Figure 3 illustrates this simple and widely described (by numerous authors) knowledge and learning pyramid.

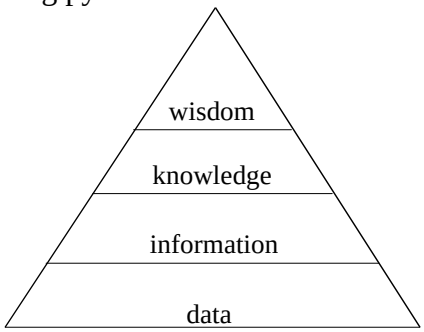

Figure 3: The Knowledge or Learning Pyramid

KM theory states that an organization must build, maintain, and capitalize on the organizational knowledge base to ensure a continuous and optimal capacity for effective

action. 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), the explicit knowledge that is captured and represented in artefacts and archives (databases, information systems, documents, procedures, manuals, records, etc.) and the technology infrastructure that enables data, information, and knowledge flow and storage between them in the performance of work and through continuous learning and knowledge processes. The characteristics of knowledge and an organization's knowledge base are such that there are many threats to maintaining it: knowledge context may change due to external environment issues or advances in technology, knowledge may be lost simply from lack of use or lack of opportunities for application, and so on. Thus the importance of continuous learning processes as a fundamental aspect of KM cannot be overstated (see Figure 4).

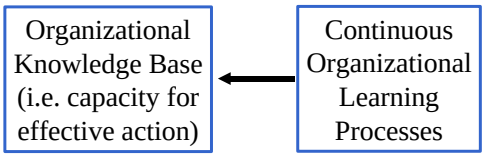

Figure 4: Continuous Learning Key to Maintaining Organization Knowledge Base

KM permeates all aspects of an organization and as a subject is difficult to grasp initially. The topic will typically mean very different things to employees in different parts of the organization, and the tendency is to view KM first in terms of the obvious implications it has on one's own work processes. However, for organizations to develop an integrated and strategic approach to KM, a deeper understanding of the breadth and depth of KM issues is needed. Achieving this typically requires a lot of discussion and many examples need to be considered before a broader consensus and meaningful insight can be achieved between various organizational sub-units. Once KM concepts and thinking become imbedded in the organization, the inter-dependencies and synergies of business processes in terms of knowledge processes begin to be appreciated and understood. Some common examples of KM shortcomings in firms would include:

- Human resources do not understand the skills needed in the Engineering Department.
- The Information Technology Department is not aware of the strategic business value of specific electronic files and records and fails to adequately archive or protect vital corporate information assets.
- Responsibility for updating important operational work procedures is not clear.
- Information is captured and produced without understanding why or for who, or how it will be used, and may not be in a form it can be easily retrieved or understood.
- Experts are too busy to mentor junior staff or assign them more difficult work that will require direction and coaching.
- Different people maintain the same information in many places in the organization, perhaps for the same or different reasons.
- Information systems don't share data effectively and as a result, slow and tedious manual data exchange processes are required.

Such examples highlight the need to view knowledge management on a larger scale to understand the impact of the ineffective use of the firm's resources, and so that more effective information flow and knowledge utilization can be achieved. The solution offered by much of the KM literature, is that firms need to focus their efforts on implementation of KM as a strategic corporate wide initiative, and this takes the form of a Knowledge Management System (KMS). There are several definitions of KMS in the

literature, but essentially it is ‘an integrated and coordinated approach to affect the management of knowledge’ (Davenport et al. 1998).

3. Knowledge Management in the Context of Nuclear Power Plants

NPPs have been doing elements of KM for a long time without explicitly recognizing it as or referring to it as KM. 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, and document management systems, etc. Despite the long history of specific KM activities, KM has not been managed in any integrated and strategic manner in most NPPs. Recently, KM has become a “hot issue” for NPPs, and for several reasons.

First, the nuclear industry is a maturing industry where recent high attrition rates have highlighted the vulnerability of NPPs to the loss of critical tacit knowledge, and measures aimed at knowledge retention have been needed. There is concern in the industry over the “pipeline” or supply of new and adequately skilled NPP knowledge-workers due to the lack of university level programs specifically targeting nuclear knowledge and 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 positions. Secondly, the aging fleet of nuclear plants will need either refurbishment or decommissioning and at the same time that new build projects are being planned and launched, creating high demand for specialized nuclear skills. Thirdly, there is recognition that licensing basis information, design basis information, and plant configuration information are critical to the continued safe and economic operation of NPPs (i.e. it must be kept up to date, accurate and correct). Fourthly, there is also a strong pressure to achieve the next level of productivity gains in NPPs, and this is driven by factors such as: deregulation and competition, rising operating costs, a move towards “lean” operations and maintenance (reduced staffing levels), and opportunities arising from new technology. Finally, there is a keen awareness that other industries are doing more in the area of KM and benefiting from these initiatives and best practices.

NPPs provide a particularly challenging environment from a KM perspective. 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; regulatory requirements that change over time; 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. Furthermore, stringent requirements for safety, environmental qualification, nuclear quality assurance, nuclear security and non-proliferation safeguards, and equipment/design configuration management must be met, all in the context of a regulated industry environment. For these reasons, the role of KM is particularly important in the nuclear industry. It is gradually becoming recognized 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. Clearly, 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, feedback from several nuclear utilities indicates they are not always able to determine the effectiveness of KM processes, and in some cases are not able to clearly 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 alignment of knowledge processes in NPPs.

NPPs are very much knowledge-driven organizations. Wigg (2000) provides a useful model to help appreciate this (Figure 5). Intelligent-acting "knowledge workers" go about their day-to-day work routines in all areas of the organization (operations, maintenance, technical support, training, etc.). Learning and continuous improvement occurs through experience gained and lessons learned. Through-out the course of carrying out work activity, 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 education and training programs are developed and captured). Learning and innovation occurs on a continuous basis, and this enables effective utilization and improvement of the structural knowledge assets.

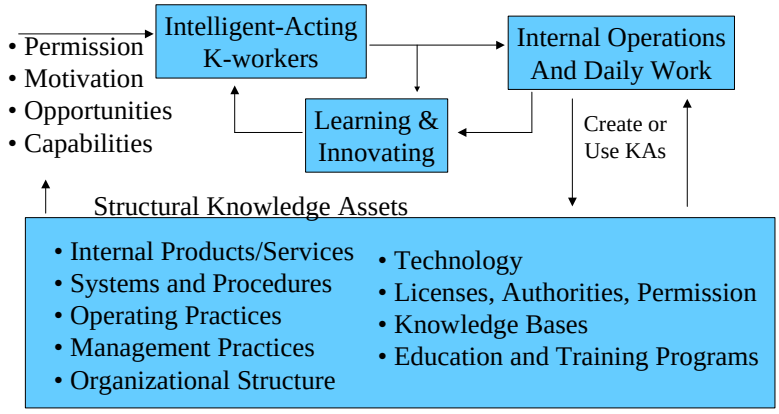

Figure 5: Firm as K-Driven Enterprise (adapted from Wigg, 2000)

All of 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 or utilize knowledge, and in general, the capabilities and capacity for effective problem solving all contribute to a pro-active knowledge driven organization. In effect, the various organizational units of the NPP, operations, maintenance, technical support, etc. all contribute to and use the collective knowledge base, which can be viewed as an "integrated and shared knowledge base" (Figure 6).

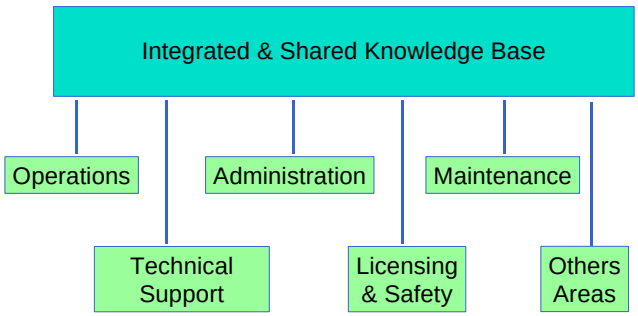

Figure 6: The Integrated and Shared NPP Knowledge Base

The research findings to date indicate the ability of an NPP to build, maintain, and effectively utilize this knowledge base depends on several factors, and this will be discussed in the following section.

4. The Link Between Knowledge Management and NPP Organizational Performance

As part of this research, a review of current literature on KM practices and its effect on organizational performance is being conducted. Also, several NPP station visits are being conducted to discuss KM approaches, lessons learned, and to aid each organization in informal self-assessment benchmarking against a range of KM criteria developed by the International Atomic Energy Agency (see IAEA Tecdoc 1510). The following sections outline the findings to date on how KM practices in NPPs may affect organizational performance.

4a. Factors and Mechanisms Involved

Initial research has revealed that the specific KM needs, priorities, and approaches at each station vary significantly depending on a variety of factors. These factors may include the effect of organizational culture, the maturity of KM culture and processes, the perception of the importance and need for effective KM, and the stage the utility is in terms of its operational life cycle. The latter of these is considered to be a key factor in determining the importance with which managers in the organization perceive a given KM issue. Figure 7 illustrates this in graphical form with points A, B, C and D representing different NPPs and their relative position on the plant operating life-cycle and indicating representative differences that may be observed on the perceived or actual importance of a given KM issue.

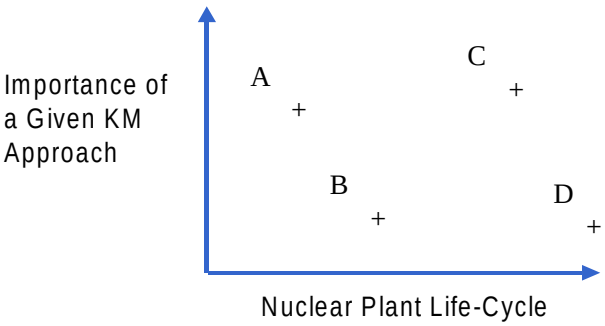

Figure 7: Varying Importance of KM Issues at Each NPP

Whether formally recognized in a given nuclear utility or not, qualitative findings to date indicate that successful and superior life-cycle operation of any NPP is dependent on

effective KM practices and processes. The degree to which knowledge process effectiveness is achieved will determine the degree to which people, work processes, and technology are synergistic and complementary and fully contribute to and utilize the "integrated and shared knowledge base" of the organization. This is influenced (and hopefully enhanced and not impeded) by the organizational culture (including leadership, values, quality and safety cultures), and this in turn promotes excellence, motivates employees to be pro-active and to strive for continuous improvement. Figure 8 illustrates these relationships with the end result being improved overall operations, maintenance and administration of the utility. Thus a key finding of the research is that the maturity and alignment of KM practices and processes in supporting NPP operational best practices (in terms of people, work processes, and supporting information management systems infrastructure) are vital and necessary ingredients to achieving superior overall long-term utility performance (see Figure 9). KM processes are believed to enhance and help maintain a pro-active organizational learning culture that focuses on problem resolution and avoidance.

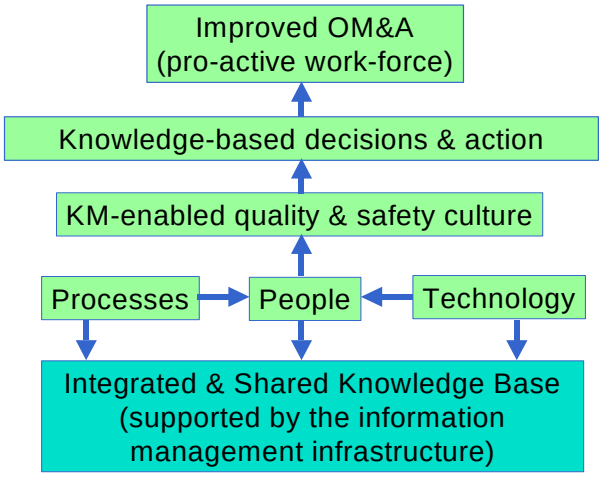

Figure 8: KM Links to NPP Performance

The mechanisms by which KM practices and processes may be linked to organizational performance can be summarized as follows:

- the requirements for and measures of performance must be understood,
- work or effort is coordinated and focused, and is aligned with larger company goals to achieve intermediate objectives effectively,
- work is achieved by the use of the firm's resources,
- decisions and actions determine what, how, when, where, and why work activity is performed,
- decisions and actions are driven by perceived needs (and priorities), as a result of sense-making processes,
- our ability for sense-making is influenced by know-how, capacity, information and knowledge,
- information and knowledge must be obtainable, acquired, relevant, correct, and current,
- ffectiveness and efficiency with which work is performed depends to a large degree on: availability of data, information, and knowledge; capacity and willingness to learn and share; and skills and experience of employees,
- this in turn depends on the adequacy of the "flows and stores" of data, information, and knowledge (i.e. knowledge processes of: knowledge sharing, conversion, and

transfer; knowledge storage and retention; knowledge acquisition; and knowledge utilization), and finally,

- the performance of the organization in meeeting overall objectives can be measured both in terms of the final outcomes and the effectiveness of these intermediate K-process mechanisms.

Thus it is evident that many KM factors contribute to the ongoing coordination, focus, and aligment of work and work processes in a firm, and continuous organizational learning is necessary for sustained effectiveness.

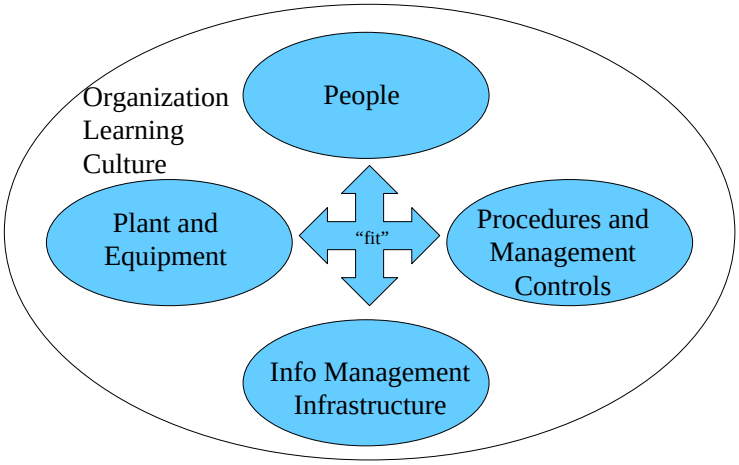

Figure 9: Importance of Aligning Knowledge Processes

This view of a value-consequence chain and the KM link to performance is found in much of the KM literature discussing organizational performance. For example, Wigg (1997) proposed the "KM Benefits Chain" (Figure 10) to show how knowledge benefits cascade to intermediate benefits and ultimately organizational benefits.

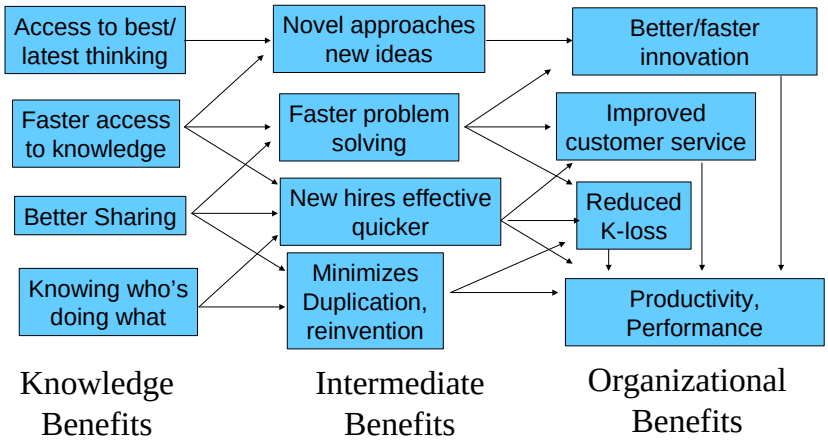

Figure 10: Knowledge Management Benefits Chain (adapted from Wigg, 1997)

Another important finding from the literature builds on the recognition that an NPP's integrated and shared knowledge base must be diligently maintained through continuous learning processes (recall Figure 4). The challenges of KM in the NPP context have also been outlined. To meet these challenges and ensure operational excellence and sustained performance, the organizational culture and practices need to include and support multiple level learning. Koorneef (2000) provides excellent insights into continuous learning processes. His model (adapted in Figure 11) illustrates further how Wigg's (2000) view of the knowledge driven organization may be extended to incorporate continuous learning processes.

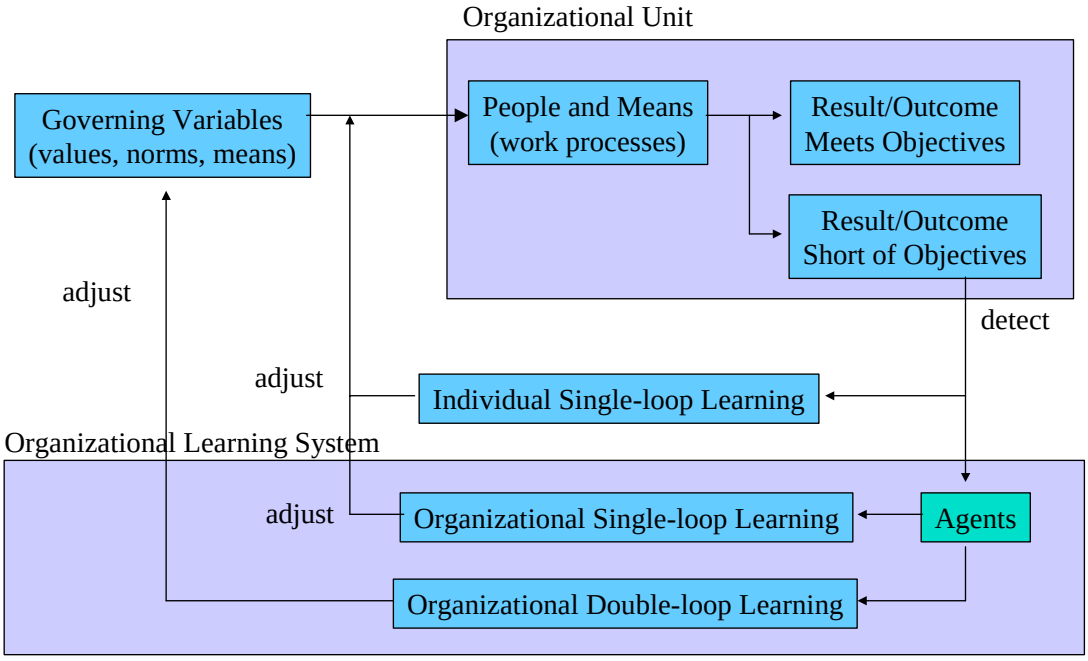

Figure 11: Organizational Learning Processes (adapted from Koorneef, 2000)

Individual single-loop learning occurs as a matter of course as the staff carries out daily duties, and adapts and typically modifies their approaches and behaviours within the constraints of the work environment. This single-loop learning also occurs at an organizational level (within teams, departments, etc.) as norms and expectations develop, accepted practices evolve, and approaches that are an interpretation and adaptation of the so-called governing variables of the firm (i.e. the values, norms, and means including work procedures, official policies, standards, etc.) mature. More importantly, double-loop learning also occurs, and this takes the form of adaptation and adjustment of the governing variables to improve overall operations. Agents (stakeholders or influencers) play a vital role in the organizational learning processes.

Earlier, in discussing Figure 9, it was pointed out that KM is fundamentally about the fit or alignment of people (and their competencies), work processes (procedures, management controls, work practices, methods etc.), and information systems infrastructure (i.e. information systems and technology support), all in the organizational context (i.e. the NPP physical plant and operational requirements) and culture. In regards to people, NPPs visited appeared to have a good understanding of the importance of maintaining core competencies in their staff, and put a high priority on training, mentoring, and learning opportunities in the organization. There has in recent years also been an increasing emphasis on retention of critical knowledge and timely replacement of key skills lost due to attrition. At most sites visited, efforts are underway to identify critical skills and positions at risk and take action to avert potential problems. In regards to work processes, significant effort appears to have been spent over the last decade developing and adopting well-defined industry operational best practices. This has been facilitated through organizations like the IAEA, World Association of Nuclear Operators (WANO), Nuclear Energy Institute (NEI), and Institute of Nuclear Power Operators (INPO). There are a number of widely accepted guidelines that describe best practice in all key areas of NPP operations. This accumulated industry knowledge base is continuously enhanced through regional community of practice exchanges, workshops, external peer reviews and audits. In short, operational processes based on industry best practices are an area of relative KM maturity and strength. However, the third key area

of NPP KM, that of the information management (IM) systems infrastructure is less uniformly developed in the industry and warrants further attention and discussion.

4b. The Importance of the Information Management Infrastructure

IM infrastructure is seen in the academic literature as key to enabling and support of effective KM, and as a necessary element in establishing and optimizing a corporate-wide KM System in NPPs. Initial findings indicate that NPP organizations however tend to view the IM infrastructure in NPPs as a way to efficiency, cost reduction, and competitiveness, but not necessarily from a KM perspective. IM systems can be in the form of any information system (IS), information technology (IT), or decision support systems (DSS). The importance of IM 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); they provide interpreted or interpretable information; they aid in knowledge generation (i.e. capture and learning, innovation); they can provide a means to identify plant system patterns and behaviours; they can provide tools to test and verify assumptions, technical premises about the plant state etc.; they can (in the case of DSSs) capture tacit knowledge in the form of "decision logic or criteria"; they can be useful support tools for capturing, presenting, or tracking processes, procedures, and work task execution; and finally, they can help maintain and make available the various data and information on the large volume of rules, constraints, sequences, inter-dependencies, guidelines, limits and conditions needed for safe and reliable plant operation. Some examples of IM systems include work management systems (WMS), enterprise application software (EAS), enterprise resource planning (ERP) systems, document management systems, Intranets, and records management. There are many more examples in a typical NPP (some are identified in Figure 14).

IM systems also offer the ability to integrate data and information from several sources. In effect, these systems provide an extension of aspects of the human capability for learning (acquiring data and information), communication (exchanging data and information), memory (retaining data and information), organizing data into information (filtering, storing), and interpreting (visualization and analysis). These properties effectively enhance or enable more effective use and accumulation of human tacit knowledge, by improving the availability, accessibility, and richness of data, information, and knowledge context. This adds relevance and meaning by providing and aiding in information building and sense making, and facilitates overall comprehension and opportunity to utilize knowledge. Figure 12 illustrates this synergy effect.

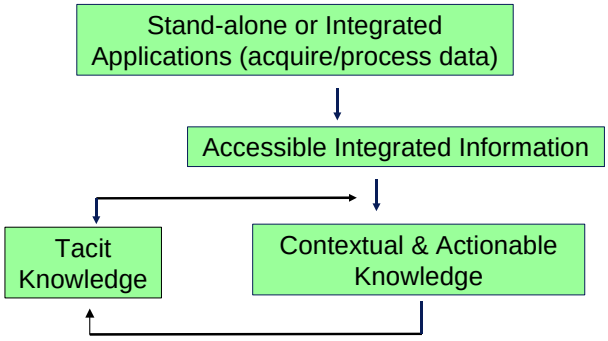

Figure 12: Synergy Effect of IM System or Tool Support for KM

DeLone and McLean (1992) provide a useful "IT and IS System Success Model" to understand how IM systems and infrastructure impact both individual and organizational

performance (Figure 13). Essentially their research has established that two key factors, the quality of the system (i.e. its design and overall capabilities, features, and effectiveness) and the quality of the information itself contained within the system will have a significant impact on system use and user satisfaction, which in turn will determine the impact (benefit) obtained by individual users and collectively the organizational impact. In the NPP context, these straightforward principles can be re-applied with the "lens" of KM thinking and perspective. Many IT, IS, and DSS systems were developed out of need at NPPs within the constraints of the technologies of the day, and over time, have evolved into complex systems and infrastructures and have become entrenched in these organizations. Often the people aspects and work-process elements of knowledge-processes are influenced or indeed constrained by the IM systems and the cost and complexity of changing or improving them may be (or at least appear to be) prohibitive.

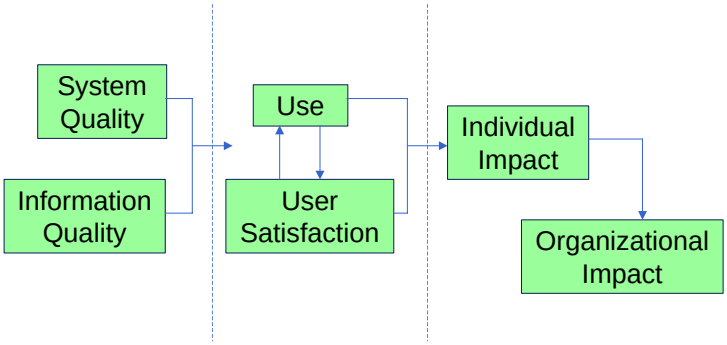

Figure 13: IS and IT System Success Model (adapted from DeLone and McLean, 1992)

In an operating NPP, the complexity and inter-dependencies of the IM system, work processes, and information flows may be daunting to the unfamiliar. There are in a typical plant, a large number of complex systems. Collectively, the sheer number, complexity, and inter-actions of these systems (both in terms of automatic or manual information flows, and/or mutual support for organizational knowledge/work processes) present a formidable challenge for even the most seasoned business process re-engineering consultant or IS expert to comprehend. Figure 14 illustrates (as an example) some of the more common IS, IT, and DSS systems seen in NPPs, and given the previous framework of Koorneef (2000), shows how the integrated and shared knowledge-base supports organizational effectiveness and learning towards the overall OM&A strategies and goals.

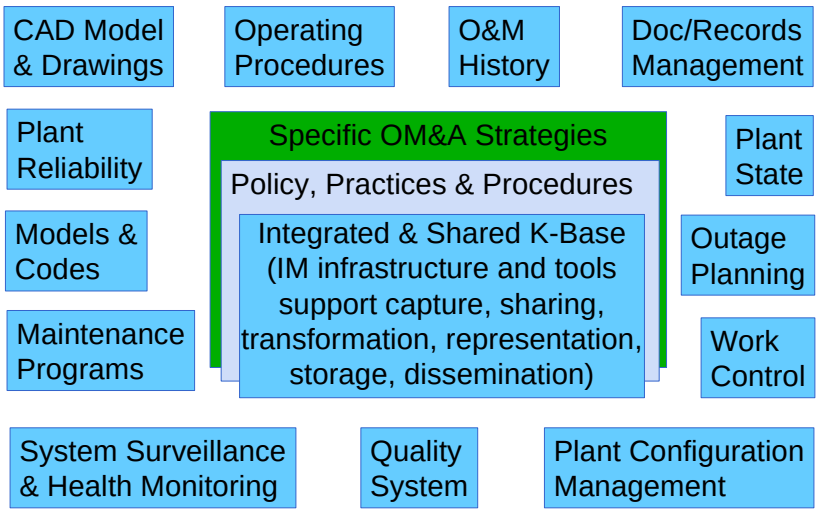

Figure 14: Examples of Typical IM Infrastructure Systems in an NPP

6. Summary

Although findings from a review of the literature and from NPP site visits support the notion of a direct link between KM and organizational performance, the challenge remains to establish with empirical evidence the nature and strength of this relationship. Furthermore, it is desirable to identify some of the contingency factors that may influence this relationship and quantify their effect. To address this question, further research is needed and is currently underway. It is generally recognized in the literature that implementing a successful firm-wide KM system depends on factors such as: leadership support, technological infrastructure, supporting culture (values, beliefs, commitment), organizational processes, and performance measurement and feedback. Many measures exist in the literature for these and related factors. One of the difficulties in conducting such research is selecting meaningful and practical measurement tools. Constructs and measures are being developed and will be incorporated in a formal survey instrument that will be administered to operating NPPs in the near future. The results of this further research will be published.

KM is an important strategic issue for NPPs, however it is difficult and challenging. It is recognized in the literature as an important driver of sustained organizational performance. Information management tools and infrastructure are seen as important contributor in leveraging knowledge-processes and achieving better knowledge creation, retention, and utilization. An integrated approach to KM is needed and KM thinking and principles need to become an embedded part of the organizational culture. Finally, a better understanding of the link between KM practices and organization performance is needed.

The qualitative research findings to date indicate successful and efficient operation of any NPPs is dependent on effective knowledge and KM processes. KM processes are believed to build and maintain the corporate knowledge base and promote organizational learning. This enhances knowledge utilization, enables organizational effectiveness, and promotes better decision-making. In an NPP operational context, this facilitates pro-active problem avoidance and resolution. By enabling better utilization of industry, organizational, departmental, and individual knowledge, NPPs with active KM systems and programs achieve better decision making and higher work process efficiency by

establishing and leveraging a knowledge-enabled work-force in a strong knowledge-sharing culture. Both tacit and explicit knowledge can be enhanced and better utilized in a more integrated and shared knowledge base when knowledge processes, flows, and stores are more strategically and systematically managed.

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