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Knowledge Management Perspectives on Outsourcing in Operating Nuclear Power Plants

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KNOWLEDGE MANAGEMENT PERSPECTIVES ON OUTSOURCING IN OPERATING NUCLEAR POWER PLANTS

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FOREWORD

Nuclear power plants operate in a highly regulated industry with strong technical and organizational requirements to ensure the safe, reliable and efficient production of electricity. While outsourcing brings potential commercial benefits, it also introduces several challenges with respect to knowledge management. These challenges relate to the potential risks associated with impaired availability of, or access to, critical knowledge that underpins safety and operational decision making. Many nuclear power plants are forced to increase economic efficiency and cost effectiveness in order to be competitive, and use outsourcing from design to operation and maintenance to reach this goal.

Depending on the outsourced service, a variety of positive and negative impacts are possible. Before the decision to outsource particular activities is made, nuclear power plant management should consider possible negative impacts, and their severity, on nuclear safety and security, environmental protection, waste management, safeguards, radiation protection and monitoring, outage planning and management, information and technology systems protection, and maintaining the design basis.

Outsourcing can offer new opportunities to the operating organization and can enhance the position of nuclear power in the electricity market. Through outsourcing, a nuclear power plant can reduce the cost of operation and maintenance, provide more accurate financial reporting, obtain a competitive advantage, gain improved public perception, obtain a better marketplace presence and, in the case of public service organizations, enhance political and community support.

Management of the nuclear operating organization needs to consider integrating knowledge management principles into decision making processes for all phases of outsourcing. Involvement of contractors in knowledge transfer and retention, and the application of the risk management principles that are described in this publication can contribute significantly to the mitigation of the potential negative impacts of outsourcing to ensure its success.

Perhaps most significantly, capture of knowledge is no longer considered an alternative approach, but is now recognized as an essential objective in the management of nuclear power plants. An integrated approach to knowledge management of outsourcing enables an organization to consider the potential impacts of risks on all organization levels, processes, activities, stakeholders, products and services. The successful application of risk management to outsourcing of work can affect the likelihood and consequences of risks, as well as deliver benefits related to better informed strategic decisions, successful delivery and management of change, and increased operational efficiency.

This publication is based on actual experiences of Member State nuclear operating organizations and is intended to increase awareness of the need to develop a strategic approach and action plans to address potential risks of knowledge loss in nuclear operating organizations when applying an outsourcing model. The IAEA officers responsible for this publication were V. Kolomiiets, M. Ovanes and K.S. Kang of the Division of Planning, Information and Knowledge Management.

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1. INTRODUCTION

1.1. BACKGROUND

Over the last decade, there has been a transition at nuclear power plants (NPPs) in a number of Member States from internal work and self-servicing to increasing use of outsourcing. The motivation for such changes has been a call for improved financial efficiency in an environment of diminishing resources and rising competitiveness.

Outsourcing is a business practice in which a company hires another company or an individual to perform tasks, handle operations or provide services that are either usually executed or had previously been done by the company's own employees.

Nuclear operating organizations act in the same business environment as other power generation companies. Based on the various reasons, operating organizations make decisions as whether to outsource certain processes and use external service providers. Additionally, operating organizations try to improve their effectiveness by means of organizational changes that can lead to redesigning and improving their structure, relocation of responsibilities within the company, and other methods. In this case, we can speak about so called "internal" or "in-house" outsourcing.

Whilst the business strategy for outsourcing certain functions or activities brings potential commercial benefits, it also presents particular challenges with respect to knowledge management (KM). Fundamentally those challenges relate to the potential risks associated with impaired availability of, or access to, critical knowledge that underpins safety and operational decision making. This document sets out the key potential KM challenges related to outsourcing strategies and, in the context of those challenges, sets out an approach to: identifying key knowledge loss risks and putting in place the requisite knowledge risk management strategies. For example, outlining the appropriate KM practices, procedures and systems that ensure that the risk of impaired knowledge access is kept to a minimum.

When the evaluation of risk for loss of essential NPP knowledge is considered in these terms, many factors related to processes, organization, competence, interfaces and relationships that affect KM processes at NPP’s need to be reviewed to evaluate and predict knowledge loss circumstances and events. For example, the simplest and most common scenario for knowledge loss from external services or outsourcing is the basic failure of a contractor or supplier to provide all required information and knowledge associated with a delivered service or item.

The study of NPP knowledge-loss events includes a failure scenario analysis to determine:

- details of what information and knowledge was required versus what was provided that did not fully meet the requirements;
- what processes may have contributed to the failure;
- what terms or lack of terms in the commercial agreements for such information and knowledge turnover may have contributed to the failure;
- what are the short- and long-term consequences of such a failure forms.

At the same time, knowledge is not the only resource at risk for loss. Competence of personnel, and ultimately, capacity may be lost through external contractors and outsourcing, not only by change, but through the loss of qualification when the supply chain for materials, services or consulting become complex and has multiple elements. In this case, personnel employer identification, propriety and qualification of record may become ambiguous or may be neglected.

An integrated approach to KM of outsourcing enables an organization to consider the potential impact of risks on all organization levels, processes, activities, stakeholders, products

and services. A successful application of risk management to outsourcing of work can affect the likelihood and consequences of risks, as well as deliver benefits related to better informed strategic decisions, successful delivery and management of change, and increased operational efficiency. Other benefits include the reduced cost of capital, more accurate financial reporting, competitive advantage, improved perception of the organization, better marketplace presence and, in the case of public service organizations, enhanced political and community support.

1.2. PURPOSE

The overall purpose of this document is to assist the management of operating organizations and NPPs, throughout outsourcing activities and external services, in identifying and implementing an appropriate KM strategy and a proactive position in acquiring new organizational knowledge and the competence needed for operating NPPs.

The methodologies provided are applicable to outsourcing for all phases of the NPP life cycle including preparation, design, construction, operations, long term operations, and decommissioning. However, the guidance provided in this publication focuses primarily on the operational phase. In addition, the document provides practical guidance on applying a knowledge reliance impact analysis for improving an NPP's performance to address unexpected risks and to capture and retain core knowledge and competency.

The primary target audience for this document is managers of NPP owner/operator (O/O) organizations, including those in NPP contracts and procurement organizational units. Additional users for this document are regulators who license NPPs and review processes and procedures.

1.3. SCOPE

While this document applies primarily to NPPs and focuses on operating plant processes, it also may be relevant for other nuclear organizations, such as research facilities, technical support organizations, academic facilities, and nuclear fuel cycle facilities. In addition, NPP vendors and engineering, procurement and construction (EPC) firms may find this document useful. The document covers the following objectives:

- increase awareness among NPP managers of the need to develop a strategic approach for a knowledge management programme to support outsourcing implementation;
- underline the opportunities for NPP organizational learning and capacity building resulting from outsourcing;
- determine the proper mix of proactive measures to capture, transfer and retain knowledge by the organization for outsourced or third-party work processes.

1.4. STRUCTURE

Section 2 identifies the learning capabilities available to an NPP O/O through outsourcing. Section 3 describes the challenges to be considered when the outsourcing is planned. Section 4 discusses applying KM to outsourcing. It describes the key elements of the KM strategy and presents guidance for organizations on how to use knowledge management approaches to mitigate potential risks and use opportunities arising from outsourcing. Section 5 provides guidance for impact and risk analysis with respect to outsourcing, while Section 6 provides a summary and conclusions. Appendixes to the document provide a KM risk assessment framework and guidance for outsourcing, as well as means for assessing contractor

competences. Case studies in the annexes provide practical examples of how the NPP operating organizations are applying knowledge management for outsourcing.

2. LEARNING OPPORTUNITIES THROUGH OUTSOURCING

In the nuclear industry it is evident that varying amounts of design or maintenance work needed for the safe operation of an NPP are obtained from external sources. This need for outsourcing varies by country and by NPP based on national industry capabilities and government policies. Nonetheless, this outsourcing has a direct impact on the ability of NPP operating organizations to access, capture and utilize knowledge sourced from contractors, subcontractors and suppliers.

Many NPP processes would be prohibitively expensive or unrealistic to bring inhouse or acquire internal competence, and therefore NPP operating organizations rely upon contractors and suppliers to supply equipment and services. Even in those cases where skills are fully acquired, or a contractor is absorbed and brought inhouse, the procurement, testing, qualification and mounting of components will still need support from a contractor and some specialized, outsourced skills.

Each scenario for work or procurement that involves an external source of materials or services is nonetheless an opportunity for learning and acquiring new competences within the NPP organization.

- As the NPP staff gain experience, it is possible that the competency level increases to the point where some previously outsourced work may be at least partially completed or supported inhouse at less cost and with an increase in NPP participation;
- Tasks augmented with NPP staff in this manner, even on a small scale, can benefit from a significant improvement in knowledge capture;
- Any time that the NPP staff can act as a redundant, “backstop” for contractor work processes, plant safety and work safety conditions can only improve.

2.1. ACCESS TO EXTERNAL EXPERTISE AND TECHNICAL COMPETENCE

Properly and proactively managed, outsourcing can provide the basis for knowledge acquisition whereby an organization that does not have access to resident expertise and knowledge, works with an outsource organization to assimilate some, or all, of that organization’s expertise and knowledge into the NPP organization.

When using outsourcing as a means to longer term knowledge acquisition (and self sufficiency) there are a range of knowledge management approaches that may be deployed. For example, communities of practices (CoPs), peer groups (PGs), working groups or other forms of professional groups focused on knowledge/information sharing are effective tools for knowledge transfer and retention. Some operating NPPs use CoP based on activities to ensure sustainable improvement of their processes.

As staff familiarity grows, the transfer of tacit knowledge increases as trust and the collaboration environment improve. Collaboration of the operator's and contractor's personnel within such groups can provide support to solve problems occurring during operation, outages, etc. The contractor's involvement keeps contractor personnel informed on processes and changes within the operator’s facilities. In addition, contractor personnel will gain new knowledge which may be utilized in the course of providing services to the NPP. From the other side, the operator's personnel will likely increase the level of their own knowledge and competences while increasing familiarity with the best practice of the contractor.

Formal training programmers may also be developed to support such knowledge transfer and acquisition; as well as the use of employee secondments between the organizations.

2.1.1. Acquiring necessary technical knowledge

The O/O needs to identify the knowledge to be transferred through outsourcing, and then develop plans to absorb this knowledge. These plans should address the human resources, data collection, IT systems and documentation control system to manage knowledge gained from outsourcing. Standard contract clauses should be included to ensure knowledge transfer from the contractor to NPP staff.

Access to external competence, such as new solutions, enhanced technologies, etc. should include familiarization with the contractor's approaches and procedures. This could improve in-house governance and provide information on third party knowledge and expertise and best practices used through the industry.

2.1.2. Build and strengthen internal capacity

Joint performance of outsourced activities and development of project deliverables are valuable tools for capacity building. Working together with contractor or supplier in performing NPP activities contributes to development of a pool of qualified experts and workers. This facilitates recruitment/succession planning and provides an available, ready to use supply of talents. Potential acquisition of skilled staff from contractors or suppliers when circumstances permit, such as recruiting redundant contractor or supplier personnel or the transfer of contractor or supplier experts to the NPP staff ensure sustainability of company human resource development.

During outsourcing, contractors exchange concepts and experience, bring lessons learned, and tacit knowledge captured through their interaction with other contractors, suppliers, vendors or consultants. Knowledge transfer from "face to face" interaction with contractor's employees, joint NPP and contractor staff interaction, and staff mentoring by the contractor provide additional competence building. Finally, improvement of each organization’s training programmes using proven methods and techniques will strengthen the training/qualification capacity of the company.

2.1.3. Build and strengthen internal KM system and tools

The emulation of processes and organizational structure and methods observed from contractors, particularly those with more experience or a highly specialized technical discipline, is a good source of knowledge transfer. However, capacity to absorb and effectively utilize this knowledge depends on the quality and maturity of internal KM processes and tools. In this regard outsourcing provides opportunities to strengthen internal KM processes, reinforce KM functions, and introduce and deploy necessary KM tools as well as motivate employees to use these tools.

Strengthening internal KM practices is particularly important for embarking countries, who need to rely heavily on transfer of knowledge from the NPP contractors and suppliers. The availability of infrastructure and proven examples of information management systems (IMS)[1], configuration management (CM)[2, 3], quality assurance (QA), and design change control (DCC) for key NPP programmes and processes is important for safety. In this regard, acquisition of technical insights regarding the design bases and safety cases for components and systems, as well as design processes are coming into more common deployment through

design knowledge turnover and workflow systems. Capacity to effectively utilize such systems depends on having a robust KM system in place.

2.1.4. Ensure knowledge integrity throughout the NPP life cycle

Major projects such as refurbishment, design reconstitution, periodic safety review, and power uprate, usually involve extensive outsourcing. These projects can serve as drivers to identify knowledgeable and competent contractor sources. Providing potential contractors with the input data and knowledge necessary to implement contracts, helps the NPP to identify all their necessary design knowledge, create an organizational competency map and thus improve its general situation regarding knowledge, documents, and data integrity.

3. KNOWLEDGE MANAGEMENT CHALLENGES RELATED TO NPP OUTSOURCING ACTIVITIES

This section describes the factors to be considered when developing an outsourcing model to ensure that knowledge and information are transferred to the NPP organization, and that proactive steps are taken for its retention. In many cases, the sharing of knowledge from processes involving the NPP and external sources is a two-way path. Inevitably, when outsourcing there is a reliance upon external knowledge and competence sources including:

— component suppliers and vendors;
— external skilled crafts (e.g. welding, fuel load, instrumentation and control (I&C) technicians);
— individual consultants and staff augmentation personnel;
— technical support organizations;
— inspectors;
— design and EPC firms;
— owner's engineer (or architect engineer);
— principal construction subcontractors.

3.1. CHALLENGES FACED BY OPERATING ORGANIZATIONS

The following subsections provide descriptions of typical KM challenges that these organizations face, as well as recommendations for overcoming these challenges.

3.1.1. Ability to absorb knowledge from outsourced work

Challenges: Even when all available knowledge is successfully transferred from an external source to the NPP, the ability to understand, preserve, utilize and ultimately absorb the knowledge into NPP work processes and business and management goals determines the true success of knowledge transfer and reduction of knowledge loss risk.

Recommendations: Ensure that the required knowledge transfer is identified and clearly stated in the work contract and agreements, and that the media and format are specified to be compatible with the existing NPP IT infrastructure. If possible, the external organization should be familiarized with the procedures affected by the work and knowledge transfer to understand the context for use of the knowledge.

3.1.2. Strategy for short and long term outsourcing and its impact on knowledge loss risk

Challenges: Outsourcing can have different durations and scopes, anything from refuelling outage support or a specialized training class, to extended consulting or continuous services during NPP operations and maintenance. Reviewing requirements for knowledge, including the completeness and accuracy of knowledge transfer, are dependent upon not only the size of the work, but its safety impact and effect on future NPP operations and potential long term operation. However, work scope cost or duration are not the sole indicators of the volume or complexity of knowledge transfer. Short duration work tasks with a high safety significance, unfamiliarity or technology transfer may need more knowledge transfer than longer tasks. See Figure 1 to see the impact of outsourcing.

Recommendations: Short term contractor relationships will need very strict knowledge turnover control, based upon the limited time available to ensure that all knowledge is shared, verified and delivered, it is therefore very important to ensure that transfer is made during or prior to exit meetings for the work. Long term contracts will likely have an increased scope and size, however also offer a longer period of time to ensure knowledge turnover, as well being able to better fit into the context of NPP operations. In this case, periodic knowledge transfers should be made at intervals or logical inflection points during the work period.

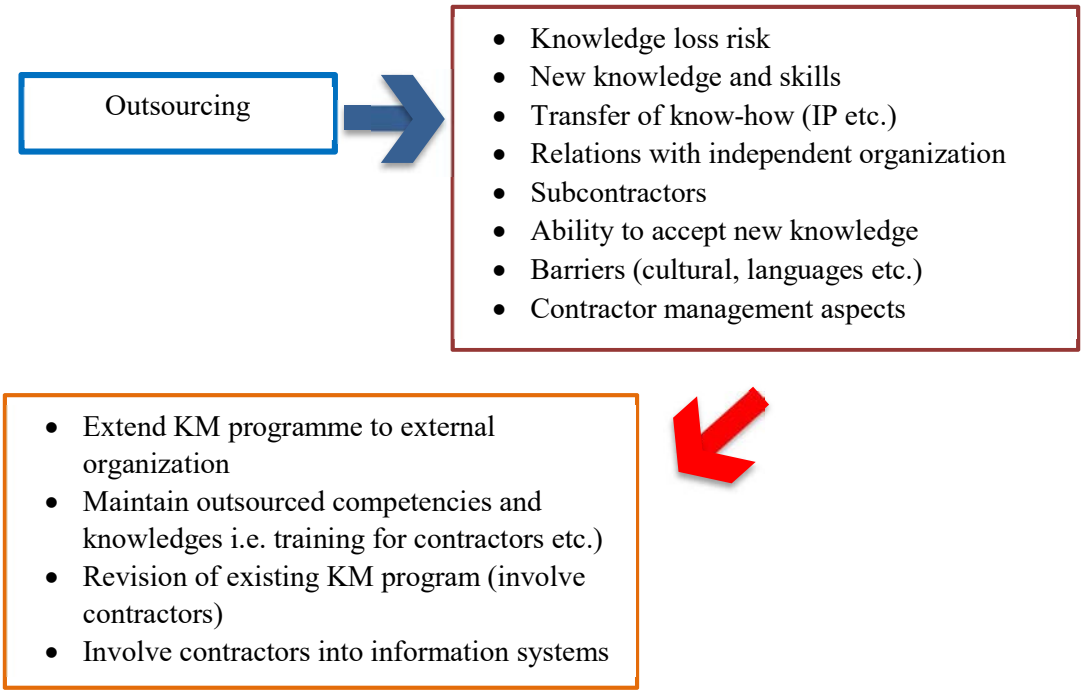

FIG.1. Impact to knowledge transfer and retention

3.1.3. Dealing with IP and proprietary information issues and contract limitations

Challenges: Virtually all commercial entities, including NPP's and nuclear service and supply contractors, have nondisclosure requirements for Intellectual Property (IP), trade secrets and other types of controlled information, the sharing/transferring of which may be specified by contract terms and nondisclosure agreements to be executed between the NPP and the contractor. Such IP policies should be balanced against knowledge transfer and exchange

requirements. Another type of IP involves national security and foreign export knowledge, which may be restricted due to state or country laws.

Recommendations: The transfer of knowledge and information to the NPP that is considered proprietary by a subcontractor should be negotiated between the two parties. When an agreement cannot be reached, the NPP needs to reconsider the true need for such knowledge that cannot be shared for proprietary and trade secret reasons, taking into account the experience and precedent of similar sister NPP's. In this case, the NPP may also consider negotiating and contracting for the information to be delivered in an alternate form or manner that will not violate IP rules. National security knowledge transfer issues usually come from the design and construction of an NPP by another country and/or foreign EPC, and such understandings for transfer should be clearly explained and settled during high level diplomatic negotiations for the NPP project. Legal counsel should be engaged and retained to help review and negotiate IP-based knowledge management issues.

3.1.4. Work break down through the supply chain

Challenges: Many external contractors and suppliers are likely to subcontract a portion of their services or materials supply to one or more third parties. From a nuclear contractor qualification and QA standpoint, contractors may only do this under a strict set of rules and requirements, and the same also applies for knowledge transfer. Well written contracts for NPP external contractors should include: controls over who the third party(s) may be, their qualification to perform or supply to the nuclear industry, what they will supply or do, and what knowledge transfer requirements are placed on them. The main contractor or supplier, as the contract holder, should be nonetheless ultimately responsible to ensure that the agreed knowledge transfer terms are satisfied, and that loss risk is controlled or reduced.

Recommendations: Just like quality management systems and manufacturer audits are used for verifying contractor qualification, the NPP QA and procurement processes should include a review of KM based requirements for contractors, including availability, access, transfer methods, capacity and compliance to NPP contract requirements, as well as qualification and competency reviews of contractor staff. Where additional subcontractors are involved in fulfilment of the service, such contractors' programmes should meet similar criteria. Contractor QA programmes should also include KM provisions for sourcing, control and delivery of knowledge during the work period, to both the requirements of ISO 9001 (2015) [4] plus the specific contract specifications.

3.1.5. Scheduling and priority to ensure contractor availability as agreed

Challenges: An important aspect of contracting for external services to reduce knowledge loss risk is the specification of work schedules and task/deliverable completion dates. The NPP should also ensure that the external contractor is available for work during the agreed work period and does not book other, conflicting work, which can challenge priorities and aggravate knowledge loss through overburdening processes and missing delivery dates. This is particularly important to create an environment that will maximize time and opportunity for tacit knowledge transfer between contractor and NPP workers.

Recommendations: When the NPP is qualifying contractors and suppliers, the capacity of the contractor or supplier to perform the work should be verified. A review of the contractor's or supplier's capability to perform work, history and industry reputation through contacting trade groups, industry organizations and other NPP's can assist in establishing a contractor or supplier viability. Proper processes and financial management should also be verified through

the qualification audits described in Section 3.1.4. This includes a review of the contractor QA programme and supporting plans for organization, periodic and spot controls such as work audits and hold points, and a corrective action programme (CAP) to manage resolution and prevention of deficiencies in staffing, work or quality.

3.1.6. Resolving cultural, legal and language barriers in knowledge transfer

Challenges: Cultural, legal and language requirements are challenged when the NPP project involves multiple states, countries, languages or cultures, or if the NPP is operated as a "turnkey" where frequently the principal day today NPP operator is not the O/O license holder. Opportunities for losing key knowledge items increase in these situations. Knowledge loss principles and the importance of knowledge capture and personnel competence/qualification should be made clearly and contractually mandatory for third party NPP operators in this context.

Recommendations: The NPP should first have a strong, mature KM programme as a foundation for establishing KM requirements for its EPC, contractors and suppliers. Knowledge identification, access and transfer requirements in NPP contracts for external products and services, including the master EPC contract for the construction of the NPP, should be executed in a clear, readable and non-ambiguous form. Contractor and supplier contracts should also specify working languages, working hours and days, and any cultural or customary elements for doing business in each respective country. Counsel from both countries representing all contracting parties, including potential IP issues for knowledge transfer, should review legal aspects.

3.1.7. Understanding delegation and responsibilities of outsourcing

Challenges: Similar to the above, it should be understood by all members of the external materials or services supply chain that design knowledge capture is a condition of successful contract execution and that knowledge loss risks should be understood and managed during the contract period. The NPP organization also should understand that, similar to NPP safety, design management, maintenance and other aspects of NPP operations, work and services may be delegated to external third parties, but the overall responsibility for knowledge capture, knowledge loss prevention and loss risk management remains with the NPP Owner and license holder.

Recommendations: The NPP organization should have a clear and incontrovertible understanding of its position and role as the license holder and ultimate design authority. In a newcomer state involved in the first newbuild NPP, this concept may need to be emphasized by the regulatory body through education, training, and strict oversight of design and operational activities. The NPP organization should proactively seek the support and advice of the regulator to ensure understanding of this concept. Contracts and agreements executed with contractors and suppliers may delegate work requirements for design, construction, manufacturing, and even staffing and management, but the responsibility for ultimate NPP safety and work integrity lies with the operating organization as the licensee.

3.1.8. Contractor quality requirements

Challenges: In addition to qualification for work and/or materials to be supplied, the contractor needs to meet QA requirements, by having a QA plan, which should include: the

contractor's company organization and responsibilities, audit requirements, reporting of nonconformances, CAP, and other quality elements, as well as a Knowledge Management Plan.

Recommendations: In a manner similar to Section 3.1.4, quality and competence for nuclear supply and/or work should be demonstrated through audits of the contractor's quality programmes and plans, staffing, capacity to meet the contract and delivery requirements, and manufacturing qualification when applicable. Knowledge transfer and retention specific requirements should be considered as part of the contract executed with the NPP O/O, including, at least, knowledge sources, transfer format and media, and delivery schedule in accordance with the work plan. Such a knowledge plan is subject to the same quality review, audit and CAP elements as other work tasks.

3.1.9. Implementation of external control

Challenges: In many cases, typical industry standard criteria and methods for control of contractors cannot guarantee the reliability of outsourced services. In order to realize sustainability between customer and contractor, it is necessary to define and understand a mutually recognized and accepted knowledge management programme and parameters.

Recommendations: A service control methodology should be developed and implemented. This methodology should be similar to any quality management system, to include monitoring, reporting, and follow up actions. Effective features for evaluation of outsourced services include external supervision control, including a second party audit process. NPP's can use this to ensure that contractor supplied products and services comply with the requirements, based on the work contract and other applicable documents and methods for reporting and removing nonconformances and discrepancies during performance of the contract.

3.2. SPECIFIC CHALLENGES FACED BY OPERATING NPP'S

This section addresses knowledge management related considerations that should be taken into account with respect to outsourcing activities. These considerations are based on such aspects as uniqueness and exclusivity of technologies used by the NPP, intended lifetime of systems and components, license compliance, regulatory and legal requirements, expectations for long term operation and license extension, etc.

3.2.1. Qualification and competence of contractor

Challenges: Degradation of qualification and competence of the contractor during contractual relationships and its ability to meet the qualification and competence standards required of NPP can adversely affect the quality of works and services.

Recommendations: Formal KM programmes should be implemented by the contractor to ensure competence sustainability and knowledge transfer within the contractor's organization. This option should be included into contractual requirements of the operating organization. External audits carrying out by the NPP and focusing on KM aspects could avoid potential shortcomings of the contractor related to the qualification and competence.

3.2.2. Critical dependency on contractor competency and services

Challenges: The reliance of the operating organization on a contractor could result in loss of services provided by the contractor if it fails as a business, through bankruptcy, being

acquired by another company, or other circumstances. Loss of services could also occur if the contractor changes the direction of their activities or leaves the nuclear sphere, or is no longer able to, or interested in, supplying knowledge needed by the NPP operating organization.

Recommendations: Operating organizations should perform a criticality assessment of contractor competencies in terms of loss risks. If a criticality is high, proper measures should be in place such as knowledge transfer between the contractor and the NPP, maintaining a list of key personnel of the contractor with critical knowledge or skills, etc. Depending on the contractor's competency criticality, the O/O should have a reasonable number of backup contractors and suppliers capable of replacing a contractor/supplier who was failed.

3.2.3. Training regarding knowledge transfer and retention

Challenges: The contractor could fail to provide knowledge needed by the NPP through appropriate knowledge transfer mechanisms (e.g. training).

Recommendations: Typically, a provider and its staff are suitably certified and experienced on the platforms and equipment work on. However, the NPP operating organization needs to ensure that the contractor has capability to share this knowledge through an appropriate KM system. Both parties should create an enabling environment that encourages knowledge sharing and implementation of knowledge transfer tools and training in particular. Broadly speaking, a provider can realize knowledge transfer by providing virtual training, online self-paced learning, and class room instruction. On the other hand, knowledge retention can be achieved through delivering of training materials on explicit knowledge, capturing and transfer of tacit knowledge, etc.

Training services should be tailored to meet the specific needs of the organization, from the agreed levels of service to the number of people at any point in time. Such requirements should be formally specified in the contract and should be supervised during the outsourcing period.

3.2.4. Compatibility of IT systems for exchange of data and information

Challenges: Data conversion and formatting can become a problem for knowledge transfer both in terms of time and cost.

Recommendation: Reviews should be performed with regards to IT systems of the external contractor and the NPP. The review should determine whether these systems have compatibility and interoperability to ensure the smooth transfer of knowledge items without a large amount of data conversion or formatting that may introduce error and ambiguities.

3.2.5. Document management system

Challenges: The NPP could suffer a loss of significant knowledge on operations, design, processes, etc.

Recommendations: The work contract should specify the method and format of document transfer from the contractor to the NPP. Document management requirements should be included in the QA plan for subcontractor. Options may include delivery of data, document digital images such as PDFs or even hardcopy documents if necessary. In some cases (such as wet signature requirements) hard copy may be a requirement. The NPP may then scan and store document images in their document management system. For data delivery, the document management systems for the NPP and the subcontractor should be capable of (at least) the migration of digital documents, supporting metadata and knowledge. Also, if possible, the NPP

may wish to consider granting access by subcontractor to the NPP document control process, or even the supporting IMS applications [1] for document data, submission of revised documents, and other document management functions.

3.2.6. Contractor understanding of NPP configuration management requirements and processes

Challenges: Safety and performance could be negatively affected if the contractor fails to meet CM requirements [2, 3]. For example, the NPP could fail to receive knowledge on the as built condition of the equipment.

Recommendations: Contracts to support the NPP should clearly describe the CM process utilized by the NPP, and instructions to the contractor or subcontractor for following this process, such as submission of work orders and history, equipment item identity and metadata. Also, the NPP may consider granting access by contractors to the NPP's master equipment and/or materials/parts process, or even the supporting MIS applications, for equipment identity, determinant data, configuration changes, and other equipment and parts management functions.

3.2.7. Planning and scheduling

Challenges: Insufficient knowledge transfer (or exchange) could have an impact on the accuracy and completeness of planning and scheduling processes. Other NPP business processes could also be adversely affected.

Recommendations: The work contract with the contractor should clearly describe the planning and scheduling process utilized by the NPP, and instructions to the contractor for following such a process. Also, if possible, the NPP may wish to consider granting the contractor access to the NPP planning and scheduling software tools (such as work management system, etc.) or provide proper training. Furthermore, the contractor could participate in the NPP working groups dealing with work management issues.

3.3. SPECIFIC CHALLENGES FOR NEW BUILD NPP

When starting a new NPP build project, or when a newcomer country commences a national nuclear programme, several scenarios and factors impacting knowledge capture may be observed, depending upon the NPP's particular requirements.

3.3.1. Lack of familiarity with nuclear industry practices

Challenge: A new NPP build project is more challenging for a newcomer country, since they likely do not have a workforce that has the skills, knowledge and experience necessary to support a nuclear power programme. They need to establish bilateral and multilateral arrangements with experienced partners to develop needed competences. IAEA Member States have established various initiatives to facilitate capacity building in countries adding nuclear power to their energy supply.

Recommendations: Newcomer countries or expanding countries need to build on the experience of countries with established nuclear programmes and by working with international organizations. They need to establish bilateral and multilateral arrangements with experienced partners to develop needed specific knowledge and skills. IAEA Member States have established various initiatives to facilitate capacity building in countries adding nuclear power to their energy supply.

3.3.2. Joint owned or venture and turnkey NPP projects

Challenge: Alternative NPP financing and construction models place an extra boundary layer of management and contractual structures between the NPP and external contractors, essentially making all contractors "third party" with the inherent knowledge loss risk that this introduces. While the technical complexity of a nuclear new build is widely recognized, the knowledge management challenges associated with different contracting models are often underestimated.

Recommendations: New NPP owners should not overestimate their own skills and management capabilities. For owners with only limited or moderate experience, an EPC (turnkey) approach – with a limited owner's scope and contractual structure based on a hybrid-pricing model – is often the proper solution. For joint venture new build projects, owners need to define effective decision making, steering and governance mechanisms. These mechanisms need to ensure a transparent, reliable, flexible and broadly accepted process to ensure adequate knowledge transfer and retention.

3.3.3. Newcomer state culture and language

Challenge: For newcomers, NPP turnkey projects usually introduce EPC contractors to a new environment, with business, cultural and language obstacles to be overcome. This is in addition to the fact that the new NPP is, almost always, the single most technologically advanced project in the newcomer country. As such, many principles of technical data knowledge transfer and handling of technical information through IT systems may be unfamiliar and create a significant "learning curve" to be overcome, along with the other challenges in designing and building an NPP. Most of these items are known requirements for EPC contractors, but also include added knowledge capture and retention criteria. Various national cultures may view the same thing in very different ways thus creating challenges in dealing with potential partners.

Recommendations: It is very important to determine which cultural differences are acceptable and which are not in order to create a productive environment for knowledge transfer; whether certain attitudes, behaviours, characteristics, or attributes are absolutely essential to succeed at work or it is possible to achieve objectives without them. Whenever possible, knowledge related information has to be saved and stored in bilingual format.

Knowledge transfer from one language to another is fraught with the potential for misunderstanding. The use of interpreters will mitigate the risk of misunderstanding or ambiguity. During a communication process, the general rule is to ask questions and be ready to be flexible. It is much easier to change one's own behaviour than to influence someone else's. When interacting with people from different cultures, effective communication can be fostered if a neutral tone of speaking is used and a conscious effort to be considerate to others is applied.

3.3.4. IT systems and KM approaches compatibility

Challenge: Typically, new NPP operating organizations do not have a purposefully designed KM IT system or if they do, the system has limited functionality. In that case the EPC contractor's IT tools will serve as the basis for knowledge transfer. The power of technology can be amplified if the O/O and contractor IT solutions are integrated and compatible with one another.

Recommendations: Upon commencement of the decision to build and operate the NPP, but certainly no later than NPP commissioning, a KM IT solution should be in place to capture,

preserve and provide access to needed knowledge. This system should be utilized as the repository for EPC, contractor and subcontractor data, experience, knowhow, skills and knowledge. Knowledge items may be delivered at system design turnover, after testing and commissioning and prior to NPP commercial operations. Whenever possible, such KM systems should be shared between the NPP and outsourcing companies/contractors, to enhance safe NPP operations.

Compatibility between systems should be ensured through proven technical solutions and should guarantee complex integration, proper data migration and common user interface. Even where systems are not integrated, use of compatible software is necessary to ensure that various file types such as word processing documents, spreadsheets, and data files, can be shared between staff in various locations without any concerns about data conversion or inability to read information.

4. STRATEGIES OF KNOWLEDGE MANAGEMENT TO OUTSOURCING

4.1. KEY ELEMENTS OF SUCCESSFUL KM STRATEGY FOR OUTSOURCING

Outsourcing activities and internal organizational changes have an inherent impact that should be considered within a decision making process. Furthermore, outsourcing is integral and inseparable from the knowledge transfer between the operating organization and external service provider. From one side, to insure successful outsourcing, the operating organization should provide a contractor with all the information requirements needed to fulfil a contract. From the other side, the contractor should share knowledge and skills with the operating organization and also with possible third parties such as subcontractors. This is why implementation of knowledge management approaches and principles is a crucial success factor of the overall outsourcing process.

As stated in previous sections, outsourcing processes present certain challenges and opportunities for operating organizations from the knowledge management point of view. A properly implemented KM strategy by the NPP operating organization should be able to mitigate the negative consequences of outsourcing and use the opportunities provided by outsourcing. From this point of view, the KM strategy needs to be focused on identification of potential risks and opportunities that could result from the outsourcing and provide effective solutions. Key elements for the KM strategy are listed below:

- KM governance through the overall outsourcing process;
- KM oversight and monitoring arrangements;
- alignment of KM activities related to outsourcing with main targets and objectives of the operating organization;
- motivation mechanisms for knowledge transfer and retention;
- feedback on knowledge transfer within outsourced activities.

4.1.1. KM governance and oversight arrangements

As part of KM considerations regarding outsourcing, the NPP organization should ensure that adequate KM oversight and governance arrangements are in place. These arrangements should cover the duration of an outsourcing contract, i.e., from the outset during the tendering process through to the termination of a contract. It is likely that these arrangements would

augment existing contract and/or project management processes and procedures, and should, for example, encompass:

- sponsorship and/or ownership of KM within the outsourcing contract;
- responsibility for ensuring an adequate assessment of knowledge risks and development of an appropriate KM strategy for outsourcing contracts;
- establishing KM related criteria in the overall contractor selection process; and the subsequent assessment of tenders against such criteria;
- the definition of roles and responsibilities for overseeing KM with respect to service delivery and performance;
- document management system and provision for IT infrastructure, information services and KM solutions;
- ensuring adequate resources in terms of competency of staff, budget, and other relevant resources;
- ensuring availability and quality of relevant information and knowledge to support the contractor in execution of its tasks (i.e., inputs, processes and outputs);
- ensuring lessons learned with respect to KM performance; before, during and after an outsourcing contract.

4.1.2. Alignment of KM activities with goals and objectives of the operating organization

In generally, a strategy could be considered as a set of goals and practical actions needed to achieve those goals. Taking into account the outsourcing issues and knowledge management aspects, the proper KM strategy should be in place in an organization that will define the goals and objectives of KM towards the outsourcing and describe the policies (means) facilitating those goals. KM strategic goals address the followings:

- expansion of sources of information on contractors, suppliers and outsourcing organizations;
- improve the degree of KM implementation at the corporate level across processes due to the necessity of cooperation with the independent entity on a long-term basis with a measurable economic impact;
- succession planning and key expert stabilization not only in house but in the area of the open market for external company;
- possibility of applying NPP employee and professional skills in outsourced activities;
- improvement of change management via interfaces channels between the NPP and the contractor or supplier;
- improvement of capacity planning and scheduling because of necessity of clear formal definition of interfaces between company activities;
- reinforcement of owner responsibility for processes;
- unification of all interface settings among the client company and the contractors and suppliers;
- regular training of the contractors and suppliers;
- improvement of the evaluation of labour productivity;
- improvement of coordination skills;
- access to information from operational experience feedback and problem solving.

4.1.3. Developing a KM strategy for outsourcing

The KM strategy should describe how the goals can be achieved using available means. To design the KM strategy, an organization needs to analyse the environment related to outsourcing. This phase should include an impact and risk analysis of outsourcing. Practical guidelines for this analysis are described in Section 5. Based on the results of the foregoing analyses, the goals could deal with enhancing operational excellence or focus on innovations such as creating and acquiring new knowledge.

Once the goals of the KM strategy have been set, the organization should define the policies and resources that will be support the KM strategy. Those policies and resources should enable the NPP to implement suitable knowledge management tools and approaches to mitigate negative consequences and use the opportunities available through outsourcing:

- KM processes should be incorporated into the integrated management system. This will ensure that KM tools (such as knowledge loss risk analysis) will be used systematically during preparations for outsourcing;
- Impact analysis should be applied during the outsourcing planning phase. By transferring activities to contractors, a risk exists that the NPP operating organization will lose control of certain competences. Risk analysis will identify the knowledge at risk;
- KM processes should include suitable tools to capture the knowledge of contractors and transfer it to NPP staff.

4.1.4. Motivation and feedback mechanisms to sustain the KM strategy

To provide successful and sustainable implementation of KM within existing outsourcing activities it is important to pay attention to motivation and feedback mechanisms for knowledge transfer and retention. These two components play a significant role in forming an organizational culture that ensures knowledge sharing between the NPP and contractor organizations. Contract conditions related to information and knowledge exchange are not enough of themselves to ensure desired outcomes. Strategic focus to build trust, motivation and positive feedback from working with each other in collaborative manner can complement these contract conditions. The following are key points:

- The contractor should be aligned with the NPP's knowledge sharing culture supporting knowledge transfer between the contractor and the NPP;
- The operating organization should consider the use of motivational tools (such as special awards for contractors for knowledge sharing) to support knowledge sharing;
- Leaders should support knowledge transfer in both directions (from the NPP to the contractor and vice versa);
- Feedback from knowledge sharing activities should be used to encourage, motivate, and improve knowledge and information exchange between the contractor and the NPP.

5. KNOWLEDGE MANAGEMENT IMPACT AND RISK ANALYSIS OF FOR OUTSOURCING

5.1. IDENTIFICATION OF NPP PROCESSES AND FUNCTIONS IMPACTED BY OUTSOURCING

Knowledge transfer and turnover, and the associated risk of knowledge loss, need to be evaluated on a process oriented basis. The process descriptions utilized in this document are examples and are applicable to operating NPP's worldwide. It should be noted that the decision to outsource not only depends on how critical or how important it is to NPP safety, but also the availability of a competent contractor, or even legal or operating license requirements. Each scenario has its own knowledge loss risks and methods for knowledge capture and retention.

Appendix I provides a list of NPP activities within existing processes that are candidates for outsourcing.

5.1.1. Core processes

Core processes are those that are directly associated with "making electricity", as well as containing many of the processes, procedures and requirements that satisfy the terms and conditions of the NPP operating license and safety requirements. These include operations, maintenance, design engineering and technical support. Depending on site specifics, other functions of the NPP could be considered as a core process. These processes implement the majority of the safety functions for the NPP, and are closely associated with the physical plant, the design basis and CM.

Many of these core processes cannot be outsourced, either due to unavailability of qualified contractor personnel, or license and legal requirements. By law, emergency operations are generally, not allowed to be outsourced. When a core process is outsourced, the consequences of failure to completely transfer outsourced knowledge can be severe; Even though the risk of such failure is often deemed relatively low when the contractors involved are knowledgeable of the core process and have long experience in NPP work.

As a part of operational processes or as a separate process, testing and commissioning of systems for a new NPP, will often require expertise or experience that the NPP operating organization has not obtained yet. In this case, the documentation, data and knowledge transfer requirements should be defined carefully, and the turnover of such knowledge needs to be a condition of final system acceptance. Again, external contractors should be selected for experience and competence in this area.

Maintenance functions that are most suitable for outsourcing are of a repair or project nature, such as the overhaul of a component or the installation of a NPP design change. Those functions that involve operating systems, inspecting the NPP or performing license-based surveillances and tests often cannot be outsourced, unless the component or system is sufficiently specialized or requires manufacturer inspection or test. Most such inspections and tests are performed during outages or shutdowns. In any event, maintenance oversight and management cannot be outsourced or seconded.

A number of design functions are routinely outsourced; many large NPP fleets have a consolidated design organization integrated with O/O management functions. Some important design change conditions should not be outsourced, or, if they are, should be closely supervised. These functions mainly need to do with management of design changes and the ability to prepare proper design documentation that accurately captures the design basis, NPP physical changes, and procured parts and components.

5.1.2. Supporting processes

Supporting processes include those related to managing finance, schedule, personnel and the NPP infrastructure. These processes are often suitable for outsourcing with some logical exceptions such as QA functions and asset management decisions that rely heavily on internal NPP experience and decisions. Likewise, NPP many operating organizations have chosen to outsource security functions but have chosen to keep safeguards controls internal.

The supporting processes shown in Appendix I are provided as examples only, as there isn't a consistent classification approach among all NPP operating organizations. For example, some NPP organizations consider training and qualification, and document management as core process.

5.1.3. Managerial processes

Managerial processes address NPP mission and policy, the strategy for achieving policy objectives, business approaches and relationships. In general, there are limited opportunities for outsourcing managerial functions. However, some managerial functions, especially those, related to human resources have intrinsic KM elements of competence management and qualification tracking and they could be considered as supporting processes, at least for certain requirements and attributes. In case of outsourcing it should be clearly noted that the ability to manage competence and qualification can impact important aspects of the KM model, and knowledge loss risk can be significant for these aspects of human resources.

5.2. IMPACT ASSESSMENT FRAMEWORK

An impact assessment framework (see Table.1) can be used to support an initial assessment of KM strategic requirements associated with a given outsourcing scenario. The aim of the framework is to support management in making an initial decision ('first filter') regarding the strategy and governance that may be needed. It looks initially at the class of main process that relates to the services being outsourced (core, managerial and supporting), the extent to which that process is usually outsourced (or for which there is prior outsourcing experience). The framework then contains a number of further criteria that can be used to help decide on a particular course of action.

Based on the results of the impact assessment a more detailed risk assessment of the specific services and/or tasks being outsourced can be carried out. From that risk assessment specific mitigating measures can be identified (e.g. knowledge management tools, methods and procedures).

TABLE 1. IMPACT ASSESSMENT CRITERIA

Criteria	Values		
	3	**2**	**1**
Process type	Core process, not commonly outsourced	Core process commonly outsourced or noncore process not commonly outsourced	Noncore process commonly outsourced
Importance	Involves creation and/or use of knowledge highly important to safety or business operation	Involves creation and/or use of knowledge important to safety or business operation	Does not involve creation and/or use of knowledge important to safety or business operation
Term	Involves knowledge needed over long term	Involves knowledge needed over medium long term	Involves knowledge needed for short term
Recovery	Involves knowledge that cannot readily be recovered or acquired from elsewhere	Involves knowledge that can be readily recovered or acquired from elsewhere but at significant cost	Involves knowledge that can readily, and at low cost, be recovered or acquired from elsewhere
Independence	Process execution requires significant knowledge exchanged/shared between contractor and NPP	Process execution requires some knowledge exchange/sharing between contractor and NPP	Process execution requires little or no knowledge exchange/sharing between contractor and NPP

Using these, criteria each process or function can be evaluated. The sum of individual criterion values presents an impact assessment rating corresponding to the KM & outsourcing strategy shown in Table 2.

TABLE 2. IMPACT ASSESSMENT RATING

Range of impact values	Response
11– 15	Process or function has potential high impact from knowledge loss. The outsourcing should be reconsidered, or robust KM Strategy and Governance should be put in place. Explicit KM contract arrangement should be mandated.
6 – 10	Process or function has potential medium impact from knowledge loss. The robust KM Strategy and Governance should be put in place. Use of explicit KM contract arrangement should be considered.
5	Process or function has potential low impact from knowledge loss. Minimum level of KM oversight should be maintained or managed through standard contract/governance arrangements.

The ranges of the impact values could be adjusted to the actual conditions. In some instances, there may be a requirement to add to, or edit, the criteria set out in Table 1. For this purpose, some additional, indicative, impact assessment criteria are set out in Table 3.

TABLE 3. IMPACT ANALYSIS CRITERIA

Additional impact analysis criteria
1. The outsourced activity has a significant knowledge element, regarding safety and security and high economic loss related risks in relation to misuse, lack of use or poor use of existing knowledge or information during work, especially during work execution on site. 2. An assessment based on the contractor's prior and demonstrable work experience. 3. Risk and cost loss in case of such knowledge being lost, including loss of contractor (e.g. because of bankruptcy). 4. Cost of outsourcing vs. inhouse work execution. 5. Nuclear safety case for the knowledge capturing evaluation. 6. Collateral benefits for capacity building through interaction with the contractor or supplier. 7. The organization isn't capable of doing the work inhouse. 8. The work must be done, must be outsourced, and knowledge capture is not a decision factor. 9. How critical the process is to overall NPP safety and viability? 10. How many interfaces the process has with other NPP processes and stakeholders? 11. Are there particular service or material/components involved? 12. Are there specifications in the contract for knowledge capture? 13. What is the degree of technical interaction with the external contractor? 14. How strongly the contractor resists sharing of proprietary or "trade secret" knowledge? 15. What is the amount of formal data and documentation usually provided for such a service? 16. Compatibility of IT between the NPP and contractor? 17. Information loss because of cybercrime. 18. Language / translation problems. 19. Lack of awareness of the value of information. 20. Risk of loss of critical expertise. 21. How comfortable the contractor is with knowledge transfer tools, such as CoPs, peer groups, and handover processes? 22. What is the relative opportunity for implicit knowledge to be transferred? 23. How much work or supply is provided by third-parties and subcontractors? 24. What is the method, timing, and scope of knowledge expected to be shared e.g. plant information model? 25. What is the quality of the relationship and familiarity of the NPP with the contractor? 26. How to measure, and the indicators required for, knowledge being shared? 27. What is the duration of the work contract? 28. Is the contractor experienced in both the work to be performed and knowledge transfer? 29. Necessity of contractor support via budgeting or technical support ? 30. Necessity of tacit knowledge sharing. 31. Is there an established method for just in time distribution system of important shared information before the start of relevant work, (e.g. information from the operating experience feedback system for job briefings)?

This impact assessment methodology is a first filter in the identification of potential difficulties related to knowledge loss due to outsourced activities and processes by the owners' activities or processes being considered for outsourcing. As soon as critical areas are identified through this methodology, next step is a detailed risk assessment using the methodology provided in Section 5.3 and supported by Appendix II.

5.3. RISK ASSESSMENT GUIDANCE

Risk Management can be helpful with managing the knowledge risks which come with the outsourcing of a NPP process. Typical steps in the risk management process are to:

1. establish the context;
2. identify risks;
3. understand the risk (causes, consequences, probability);
4. determine the risk classification (low, medium, high);
5. make decision;
6. select / develop measures;
7. implement the measures;
8. monitor the effectiveness of the measures.

The steps of the risk management process are briefly explained in the text below; in addition some examples related to knowledge management are provided. More information about risk management is available in ISO 31000 [5] and the IAEA-TECDOC-1209 [6].

The first step in the risk management process is establishing the context. This includes the outsourced process, stakeholders, and involved knowledge. In this step, the organization needs to identify criteria to be used to evaluate the significance of risk. The criteria for knowledge management can be based on the impact on the availability, quality (integrity), confidentiality and compliancy of the knowledge.

The second step within the risk management process is risk identification. Risk identification is the process of finding, recognizing and describing risks. Risk identification can involve historical data, theoretical analysis, informed and expert opinions, and identifying stakeholder's needs. Brainstorming is often used to guide risk identification. Some examples of knowledge risks are:

- loss of contractor (e.g. due to bankruptcy);
- lack of information sharing;
- lack of IT availability or compatibility;
- information loss due to cybercrimes;
- language / translation problems; and
- lack of awareness of the value of (on time) information.

The third step is understanding the risk. At the end of this step we understand the causes, consequences and likelihood of the knowledge risk.

The fourth step, risk classification, can be completed when the risk is well understood the impact on the availability, quality, integrity, confidentiality and compliancy of the knowledge can be classified. If only the impact is classified the result will be an impact analysis. If also the likelihood is classified the risk level can be classified into low, medium, and high by using a risk matrix.

The fifth step is to make an informed decision about what to do with the risk. The question to be answered is: Is the risk level acceptable or not? If the risk level is acceptable no (additional) measures are required.

The sixth step includes selection or development of measures to reduce the risk if the level of risk is not acceptable. There are a number of measures that can be considered; examples are:

— specific knowledge management measures in the contract;
— agreements on which IT systems to use;
— agreements on training.

The seventh step consists of implementation and integration of measures in contracts and NPP processes.

The eighth step (final step) in the risk management process is to monitor the effectives of the measures. This can be done in different ways; auditing and self evaluation are examples. The monitoring can be completed sometime after outsourcing and can be repeated periodically. The outcome of the audits can be used for improving knowledge management in the outsourced NPP processes.

These are eight steps are the plan, do, check and act cycle. Appendix II provides risk assessment guidance with a set of KM techniques that could be applied to mitigate or eliminate identified risks.

6. SUMMARY AND CONCLUSIONS

NPPs are operating under a highly regulated environment with very strong technical and organizational requirements to ensure safe, reliable and efficient production of energy. However, In order to remain competitive, many NPPs are being pushed to increase economic efficiency. Costs, revenues and staffing counts are all under pressure to be optimized, and “right sized” for efficiency and cost effectiveness. This also means that staffing numbers will be reduced to cut costs and meet austerity goals. As a result, some NPPs are reducing staff by outsourcing more activities (e.g. maintenance and design services), This creates additional risks and dependencies on outside organizations to maintain essential knowledge.

From another perspective, in some cases the operating organization "buys" certain works and services from external providers if its own staff does not possess the required knowledge, skills or qualification. All NPP operations and maintenance activities require special knowledge and competences. That is why outsourcing is impossible without transferring important knowledge and competences to an external organization. Outsourcing is therefore utilized more today as a method to “plug the gaps” in staffing and knowledge.

Perhaps most significantly, capture of knowledge is no longer considered an alternative approach, but is now recognized as an essential NPP objective. Staff turnover and reductions in force mean that tacit knowledge retention is no longer a given. Building and maintaining capacity and competence are strained as staffing is reduced, and skills are “consolidated” into fewer people, while training and professional development budgets are watched more carefully. The opportunities for staff to gain knowledge are fewer and more expensive, which leads to an intense effort to get the most from each opportunity for knowledge capture from contractors and suppliers.

Depending on outsourcing approaches used, there are variety of possible positive and negative impacts on NPP performance. The following are some of the positive aspects of the outsourcing with respect to knowledge management:

— acquiring new knowledge possessed by the contractor including access to external expertise and technical competence;
— providing internal staff with new competencies;
— possibility to use a pool of highly skilled professionals and experts;
— mitigation of valuable and unique knowledge loss risk because such knowledge is "backed up" by contractors;
— strengthening internal capacity and competence;
— improvement of business processes of the operating organization resulting from benchmarking with best practices demonstrated by contractors;
— sustainable improvement of operating organization KM programmes.

Before making decision to outsource any particular activity, NPP management needs to consider very carefully possible negative impacts on areas such as nuclear safety and security, environmental controls, nuclear waste management, safeguards, radiation protection and monitoring, work management and control, outage planning and management, information and IT systems protection, and design basis CM. Possible negative consequences could include:

— reduced safety performance and subsequent risk of unplanned shutdowns;
— delay of projects, maintenance or other activities and resultant cost increases;
— reduced IT and cyber protection and reduce levels of security;
— damage to competitive positions and greater exposure to market forces;
— reduced efficiencies such as lower load factors, increases in both planned and unplanned maintenance;
— reductions in monitoring and control.

Management of NPP operating organizations needs to consider implementing KM principles in decision making processes for all phases of outsourcing. Involvement of contractors in knowledge transfer and retention and application of risk management principles described in this document can contribute significantly to the mitigation of potential negative impacts on outsourcing and ensure its success.

APPENDIX I. **IMPACT ASSESSMENT FRAMEWORK**

The simple impact assessment framework can be used to support an initial assessment of the KM strategic requirements associated with a given outsourcing scenario. The aim of the framework is to support management in making an initial decision regarding the level of detailed strategy and governance that may be required. It looks initially at the class of main process that relates to the services being outsourced (Core, Managerial, Supporting), the extent to which that process is usually outsourced or for which there is prior outsourcing experience(see Table 4). The framework then contains a number of further criteria which can be used to help decide on a particular course of strategic action. To give rating value (e.g. 3,2, 1), see Section 5.2 Table 1, impact assessment criteria.

Once the impact assessment has been undertaken a more detailed risk assessment of the specific services and/or tasks being outsourced can be carried out. From that risk assessment the specific mitigating measures can be identified in terms of appropriate knowledge management tools, methods and procedures can be determined (See Appendix III).

TABLE 4. BUSINESS PROCESSES AND FUNCTIONS POTENTIALLY APPLIED FOR OUTSOURCING

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
Core processes							
1. Operation	Reactor operations (NI)						
	Testing and commissioning (AFS)						
	Power generation plant operation						
	Operations and maintenance planning						
	Radioactive waste						
	Emergency operations						
	Technological systems operation						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Automation, control and data acquisition						
2. Maintenance	Outage planning and management						
	Maintenance management						
	Inspections and surveillance						
	Contractor management						
	Project coordination						
3. Technical Support	Monitoring and assessment of plant programmes						
	Monitoring and analyse of equipment performance and condition						
	Operating experience review						
	Safety assessment and periodic review						
	Plant technical support organization						
	Develop plant equipment reliability (ER) and life cycle						
4. Design Management	Engineering change management						
	Configuration management						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Design requirements and design basis						
	Design knowledge management						
	Engineering support						
	Diagnostics systems engineering						
Supporting processes							
5. Project Management	Design package installation management						
	Bid package development						
	Managing acceptance criteria and procedures						
	Change management						
6. Environmental Protection	Manage environmental permits and license						
	Effluent controls						
	Thermal discharge limits						
	Nonradioactive refuse						
	Manage international environmental assessments						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
7. Communications	Internal communications						
	External communications and stakeholder management						
8. Commercial	Contract management						
9. Training and Qualification	Training organizations						
	Training schedules						
	Reports						
	Implement systematic approach to training (SAT)						
	Operator licensing/relicensing						
	Qualification records						
	Training course development						
	License certification						
10. Procurement Engineering	Qualification specifications						
	Contractor or supplier nonconformance						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Commercial grade dedication (CGD)						
	Item equivalency evaluation (IEE)						
	Purchasing specifications and requirements						
11. Meteorological	weather monitoring						
	Site condition						
	Evacuation planning						
12. Materials and Warehouse	inventory and spares safety stock/order points						
	In storage maintenance						
	Issue/return						
	Material requests						
	Commercial receipt inspection						
	Warehousing and shelf life management						
	Catalogue and stock management						
13. IT Support	software and hardware purchase and deployment						
	Software quality assurance						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Systems analyst functions						
	Network administration						
	System administration						
	User support and help desk						
14. Fire Protection	Appendix "R" review						
	Fire apparatus procurement and maintenance						
	Training and emergency drills						
	Inspections and surveillance						
	Staffing						
15. Industry Health and Safety	Program administration						
	Other inspections						
	Health inspections						
	Internal environmental inspections						
	Medical and first aid						
16. Waste Management	Assignment of rad waste level						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Rad waste management						
	Decontamination						
	Spent fuel storage and transportation						
17. Finance and Accounting	Accounting system management						
	Insurance and ANI						
	Investment and business planning						
	Payroll						
18. Emergency Planning	Manage emergency preparedness programme						
	Hold drills and exercises						
	Train staff						
	Manage facilities, including Emergency operations Facility and technical support centre						
19. Security	Perimeter control and physical security						
	Access control						
	Maintenance of facilities and procedures						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Safeguards						
	Transportation control						
	Fitness for duty programmes						
20. Licensing /Regulatory Affairs	Compliance control						
	Action items						
	TSO management						
	FSAR coordination						
	Handling violations and corrective actions						
	Periodic safety reviews						
	Regulatory requests for information						
	Manage notifications						
21. Radiation Protection	Radiation monitoring and survey						
	Radiation control area setup						
	Personal dosimetry and whole body counts						
	Rad waste storage control						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Monitoring equipment maintenance						
	Reports						
22. Quality Management	QA programme and plan						
	Internal nuclear power plant audits and evaluations						
	External nuclear power plant audits						
	Surveillances						
	Quality control						
	Procedure and manual						
	Procedure review						
	Contractor audits						
	Receipt QC inspections						
23. Document Management	Document type list						
	Version control						
	Distribution						
	Review						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Approval						
	Quality records and archive						
	Procedure index						
	Data management						
24. Asset Management	Life cycle management						
	Asset performance and condition						
	Asset amortization and retirement						
	Equity/depreciation evaluation						
	Load management						
	Asset management strategy (repair/replace)						
25. Construction and installation	Civil engineering						
	Building services engineering						
	Site management, logistics, transportation						
	Construction site management						
	Facilities management and maintenance						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Supply and store management						
Managerial Process							
26. Business operations	Strategy and corporate management						
	Decision support						
	Internal audit and compliance						
	External audit						
	Executive communication						
	Contracts and procurement						
	Legal assistance						
	Administrative operations						
	Finance and budget						
	Project coordination						
27. Human Resources	Human resources administration						
	Human resources management (salaries, employment history)						

Business process	Business function [Y/N]	Impact assessment criteria					
		Process type	Importance	Term	Recovery	Independence	Impact rating value
	Workforce planning						
28. Strategic Planning	Improvements in integrated management system (IMS)						
	Corporate planning, goals and objectives						
	Regulatory and state planning						
29. Organizational Changes	Overall corporate strategy						
	Functional and work processes						
30. Knowledge Management	programmes and planning						
	Competence						
	Succession						
	IT and portals						

APPENDIX II. **KM RISK ASSESSMENT GUIDANCE**

Appendix II illustrates the most common knowledge management related risks associated with NPP processes and functions due to outsourcing, as well as KM considerations and tools to reduce these risks.

II.1. CORE PROCESSES

II.1.1. **Operations**

II.1.1.1. *Events and causes*

Events that occur as a result of knowledge loss associated with outsourcing and could lead to the following violations of the conditions and limits of normal NPP operations:

- Discrepancy between the actual configuration of an NPP and its design configuration;
- Uncorrected calculation errors related to NPP safety criteria;
- Not applying operational feedback from other NPPs;
- The control room simulator does not adequately reflect the actual NPP configuration.

II.1.1.2. *Consequences*

Deficiencies in NPP safety and performance. Loss of expertise related to key NPP systems. Testing and commissioning methodologies and plans for implementation provided by the contractor may not be certified for application to NPP equipment and not be approved by the regulatory authority.

II.1.1.3. *Plan to reduce risk*

Implement activities for timely reception and absorption of knowledge from the contractor. Increase the quality levels of procedures and documentation in technological and business processes. KM tools to be considered to reduce risk:

- knowledge retention - capturing the contractor's knowledge and experience in operations by using the NPP’s operational experience feedback system;
- knowledge transfer/sharing - enabling contractors to use the NPP’s documentation control system;
- communities of practices - establishing peer groups or joint working groups dealing with NPP operational issues;
- competence mapping - identifying critical competences of the contractor from the NPP operations point of view;
- analysis of positions at risk - mapping contractor positions that could be critical from a knowledge loss point of view;
- competence development - providing training for NPP operations personnel to maintain competences for operations at required levels;
- competence building - involving the contractor in benchmarking programmes (e.g. IAEA, WANO) To ensure implementation of best practices;
- expert at risk identification - identification of critical knowledge holders.

II.1.2. **Maintenance**

II.1.2.1. *Events and causes*

Any events that occur as a result of knowledge loss associated with outsourcing and that could lead to damaging of SSC or to changing of SSC behaviours, for example:

- Discrepancies between the actual state of the SSC and the approved plant design;
- Obsolete maintenance methodology or technology;
- Use of out of date spare parts, etc.

II.1.2.2. *Consequences*

Degradation of work quality and deficiencies in NPP safety and performance. Delays in work schedule, degradation of safety culture, damaged assets, increased cost and outage durations.

II.1.2.3. *Plans to reduce risk*

Implement activities for timely reception and absorption of knowledge from the contractor. Increase the quality level of procedures and documentation for technological and business processes. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of maintenance by using non-compliance notification and corrective action programmes,;
- knowledge transfer/sharing - enabling contractors to use documentation control system, and development of technological procedures based on new experience;
- communities of practices - establishing peer groups or joint working groups focusing on maintenance issues;
- competence mapping - identifying critical competences of the contractor from the maintenance point of view;
- analysis of positions at risk - mapping contractor positions that could be critical from a knowledge loss point of view;
- competence development - providing training to keep competences in maintenance at required levels;
- competence building - involving the contractor in benchmarking programmes (e.g. IAEA, WANO) to ensure best practices implementation;
- expert at risk identification - identification of critical knowledge holders.

II.1.3. **Technical support**

II.1.3.1. *Events and causes*

Lack of exchange of verified information between the NPP and technical support organization (TSO) could lead to deficiencies in quality of knowledge produced by the contractor and to delays in implementation of knowledge developed by the contractor.

II.1.3.2. *Consequences*

Degradation in NPP safety and performance, delays in work schedules, degradation of safety culture, damaged assets, increased costs and longer outages. Loss of important data related to operational feedback from other NPPs. Inability to accumulate technical knowledge and experience within the organization. Decrease in understanding of the design basis.

II.1.3.3. *Plans to reduce risk*

Develop effective exchange of information between the NPP and TSO and joint ad hoc team for evaluation and implementation of specific issues. Enable personnel mobility between the NPP and TSO. Deploy information sharing system. Benchmark good practices for contractors. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in the area of technical support;
- knowledge transfer/sharing - enabling contractors to use the documentation control system, and development of relevant procedures based on new experience;
- communities of practices - establishing peer groups or joint working groups focusing on technical support issues;
- competence mapping - identifying critical competences of the contractor from the technical support point of view;
- analysis of position at risk - mapping contractor positions that could be critical from a knowledge loss point of view;
- competence development - providing training to keep competences in relevant areas of technical support at required levels;
- competence building - involving the contractor in benchmarking programmes (e.g. IAEA, WANO) to ensure best practices implementation;
- expert at risk identification - identification of critical knowledge holders.

II.1.4. **Design management**

II.1.4.1. *Events and causes*

Inaccurate data exchange can lead to an erroneous design basis and subsequent incorrect design decisions. Communication failures between NPP and designer may lead to degradation of design basis and design.

II.1.4.2. *Consequences*

Risk of serious degradation of NPP safety and performance, including challenges in administration, finance, work schedule and staffing. Loss of knowledge developed by designer may result in design deficiencies. Potential for design-basis issues (DBIs) due to poorly written contract with design contractor.

II.1.4.3. *Plan to reduce risk*

NPP and designer should create effective two – way communication to avoid loss of knowledge. Data used by designer for design modification should be verified by NPP to avoid low quality or erroneous decision on modification. System of documents traceability and effective data review mechanism should be jointly implemented by NPP and designer. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of design management;
- knowledge transfer/sharing - enabling the contractors to use documentation control system;
- communities of practices - establishing peer groups or joint working groups focusing on design management issues;
- competence mapping - identifying critical competences of the contractor from the design management point of view;
- analysis of positions at risk - mapping contractor positions that could be critical from a knowledge loss point of view;
- competence development - providing training to keep competences in relevant areas of design management at required levels;
- competence building - involving the contractor in benchmarking programmes (e.g. IAEA, WANO) to ensure best practices implementation;
- expert at risk identification - identification of critical knowledge holders.

II.2. SUPPORTING PROCESSES

II.2.1. **Project management**

II.2.1.1. *Events and causes*

Inaccurate data leads to incorrect decision making, which can lead to substantial losses, as in the implementation of decisions taken, and pose a threat to safety. Potential misalignment between project management and process management.

II.2.1.2. *Consequences*

Loss of knowledge can lead to problems with the correct implementation of project management and unexpected loss of resources and time during NPP construction and operations of the NPP. Incorrect knowledge increases probability of failures and decreases probability of success. Generally, the following risks should be considered:

- risk of losing the ability to implement effective change management, performance improvement and risks analysis;
- risk of losing the ability to form high performance teams;
- risk of loss of internal and external contacts with outsourced organization (e.g. contractor and design organizations);
- risk of losing the ability to connect with knowledgeable personnel outside of the licensee in outsourced organizations.

II.2.1.3. *Plan to reduce risk*

Knowledge used for project management should be verified and any changes in knowledge should be monitored. It is important to ensure traceability of data used for project management. Loss of knowledge and competence in project management is risky because the NPP is not typically an organization specializing in project management. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing - providing the contractor with access to operator's information system and data to ensure effective decision-making process;
- communities of practices - establishing peer groups or joint working groups focusing on project management issues (e.g. to verify the inputs and outputs);
- competence mapping - identifying critical competences of the contractor from the project management point of view;
- competence development - providing the training for contractor to keep relevant competences at required level.

II.2.2. **Environmental protection**

II.2.2.1. *Events and causes*

Presence of third party in communication between Regulatory Authority and NPP/Operating Organization could result in failure to meet time limits set for permitting and licensing processes and lead to penalties as well as degradation of comprehensive in-house knowledge of environmental regulatory aspects.

II.2.2.2. *Consequences*

Erroneous decisions as consequences of losing knowledge connected to environmental protection leads to additional safety risks and to a deterioration of relations with the public and the regulatory body, significant deficiencies in licensing processes and to penalties. Invalid environmental data (knowledge) leads to significant errors in the formation of the design basis, erroneous design decision and also to incorrect decisions regarding NPP operations.

II.2.2.3. *Plan to reduce risk*

All the data, concerning environmental protection need to be reliable and upto date. It is important to ensure traceability of data used and related records. Effective communication should be organized for timely updating of connected knowledge. KM tools to be considered to reduce risk including:

- knowledge retention - capturing the contractor's knowledge and experience in area of environmental protection;
- knowledge transfer/sharing - providing the contractor with access to operator's information system and data to ensure effective decision making process;
- communities of practices - establishing peer groups or joint working groups focusing on environmental protection issues (e.g. to inform about new requirements and limits of the regulator);
- competence development - providing the training for contractor and operator to keep relevant competences at required level.

II.2.3. **Communications**

II.2.3.1. *Events and causes*

Disruption of communication of the NPP with contractor fails to provide channel for effective and timely transmission of data from the NPP to contractor and vice versa.

II.2.3.2. *Consequences*

Delay in response to the communications, including those related to safety. Loss of knowledge on actual trends within organization. External and internal communication strategies may be ineffective and inflexible.

II.2.3.3. *Plan to reduce risk*

Creation of an effective communication system operated by joint team of NPP and contractor personnel with regular monitoring of it effectiveness. Use "teambuilding" approach where it is possible for upgrading of communication efficiency. KM tools to be considered to reduce risk include:

- communities of practices - establishing peer groups or joint working groups focusing on communication issues (e.g. to develop a strategy of external and internal communication, to inform about challenges faced by the NPP or the industry);
- competence development - providing the training for contractor to keep relevant competences at required level.

II.2.4. **Commercial**

II.2.4.1. *Events and causes*

Changes in the nature of energy marketplace competition. Changes in public sentiment toward particular lines of business. Outsourced organization is not adjusting to changes in the economic, commercial, or political environments.

II.2.4.2. *Consequences*

Inadequate and late responses to business changes will lead to additional costs and financial risks. Loss of business opportunities to adjust in a new market environment. Time delays for contracts implementation due to changes in the business environment. Potential losses due to contractual agreements and currency fluctuations when for multi-national transactions.

II.2.4.3. *Plan to reduce risk*

Benchmark good practices for contractors and exchange good practices with them. Commercial variables need to be analysed for volatility including prices of resources, prices of electricity produced and sold, credit risk of major customers, counter party risk in legal contracts, costs of financing of new ventures, probability of losses due to more than one unit being down at one time in a multiunit operating organization. KM tools to be considered to reduce risk include:

- communities of practices - establishing peer groups or joint working groups focusing on energy market issues;
- competence mapping - identifying critical competences of the contractor from a commercial point of view;
- competence building - involving the contractor into benchmarking programmes to ensure best practice implementation.

II.2.5. **Training and qualification**

II.2.5.1. *Events and causes*

Training facilities of the contractor (especially for practical training) may not be in compliance with code & standard requirements. Contractor instructors (full scope simulator (FSS) instructors in particular) may not be aware of NPP specifics and main control room (MCR) features. Contractor examination criteria may not be strictly followed. Training of contractors and sub-contractor personnel may not be included in outsourced schemes. No knowledge transfer/exchange organized due to attrition of experienced staff. Jeopardizing the training process – training schedules may not be aligned with technological planning. Inadequate content management – training programmes, training courses and exam questionnaires may not be maintained up to date.

II.2.5.2. *Consequences*

Loss of capability to support inhouse training. Loss of corporate training capacity – internal SMEs of specific training knowledge and skills could be ignored or discouraged. Due to inadequate and insufficient training, NPP cannot follow licensing and safety qualifications. Risk for sustainable implementation of systematic approach to training.

II.2.5.3. *Plan to reduce risk*

Clearly define scope of contractors work on delivering training. Hire experience personnel after retirement on a part time basis. Implement a procedure on video capturing of training provided by contractors. Put requirements on the contractor to deliver SAT based training according to NPP standards, with suitable documentation and methodology transfer. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in the area of training;
- knowledge transfer/sharing - providing the contractor with access to operator's information system and data to ensure effective decision making;
- communities of practices - establishing peer groups or joint working groups focusing on training issues (e.g. to inform about new regulatory requirements, design changes, in the NPP organization);
- competence mapping - identifying critical competences of the contractor from the training point of view;
- analysis of position at risk - mapping contractor positions that could be critical from knowledge loss point of view;
- competence development - providing the training for contractor to keep competences in relevant areas of training at required level (for instructors, etc.);
- competence building - involving the contractor into benchmarking programmes (IAEA, WANO) to ensure best practices implementation;
- expert at risk identification - identification of critical knowledge holders.

II.2.6. **Procurement engineering**

II.2.6.1. *Events and causes*

Loss of contractor or supplier network relationships. Loss of internal NPP relationships and understanding of requirements. Loss of knowledge related to procurement systems, procedures and legal requirements.

II.2.6.2. *Consequences*

Risks of delays in supply of resources and material that don't meet strategic, technical and/or legal requirements, increased costs due to weak supply chain. Inefficient procurement, especially in NPP construction projects leading to significant cost and schedule delay. Absence of spare parts impacts the operation and safety sectors, lack of the necessary parts can result in unplanned plant transients. Nonoptimal coordination between maintenance work planning and scheduling often leads to inefficiencies in the material supply process, both in labour utilization and increased cost of procured materials.

II.2.6.3. *Plan to reduce risk*

Increase the quality level of procedure and documentation in the procurement process. To define the optimal level of inventory that minimizes cost, while providing a certain confidence level that needed spares will be provided when needed. Reduce inventories and procured material costs, improve procurement and material management process efficiency while maintaining adequate availability of needed materials. Implement knowledge based procurement related to equipment and engineering services. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of procurement engineering (procurement systems, procedures and legal requirements);
- knowledge transfer/sharing - providing the contractor with access to operator's information system and data to ensure effective decision-making process;
- communities of practices - establishing peer groups or joint working groups focusing on procurement engineering issues (e.g. to inform about new regulatory requirements, equipment reliability issues, outage planning, investment projects, design changes);
- competence mapping - identifying critical competences of the contractor from the procurement engineering point of view;
- competence development - providing the training for contractor to maintain competences in relevant areas of procurement engineering at required level.

II.2.7. **Meteorology**

II.2.7.1. *Events and causes*

Probabilistic risk analysis for complex or multiple meteorological hazards can be inaccurate. Flexibility for reassessment of initial design condition or input data for safety analysis might be inadequate or obsolete. Inadequate monitoring of natural hazards such as floods due to heavy rain, tornado, earthquake, and tsunami.

II.2.7.2. *Consequences*

Lack of adequate or timely countermeasures against unexpected meteorological hazards. Delays of reflection on the emergency evacuation planning.

II.2.7.3. *Plan to reduce risk*

Assign experts for the meteorological risks who can evaluate and assess each risk. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing – informing the contractor of design conditions or input data needed for safety analysis;
- communities of practices - establishing peer groups or joint working groups focusing on meteorology issues;
- competence mapping - identifying critical competences of the contractor from the meteorology point of view;
- competence development - providing the training for contractor to keep competences in relevant areas;
- expert at risk identification – identification of critical knowledge holders.

II.2.8. **Materials and warehouse**

II.2.8.1. *Events and causes*

Inventory control knowledge loss. Extended time to update and maintain warehouse catalogue. Catalogue, stock system and contractor internal procedures and work processes subject to change.

II.2.8.2. *Consequences*

Requirements for in storage maintenance and shelf life, which are controlled by the contractor, may be changed. Contractor need to understand nuclear shelf life and re-order points for critical spares.

II.2.8.3. *Plan to reduce risk*

Clearly define and communicate expectations of contractors work for updating and maintaining warehouse catalogues and re-order points for critical spares. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of inventory control;
- knowledge transfer/sharing - providing the contractor with access to operator's information system and data to ensure effective decision-making process;
- communities of practices - establishing peer groups or joint working groups focusing on stock system issues (e.g. to inform about new regulatory requirements, equipment reliability issues, outage planning, investment projects, design changes, etc.);
- competence development - providing the training for contractor to keep competences related to nuclear installation at required level.

II.2.9. **IT support**

II.2.9.1. *Events and causes*

Loss of knowledgeable IT support professionals. Loss of records, data exchange. Loss or changes in data access, migration formats, and ownership. Loss of data and/or knowledge flow control loss.

II.2.9.2. *Consequences*

Degradation of communication between NPP departments and external organizations. Poor exchange of knowledge among IT organizations and systems have far-reaching consequences for reliability, viability and violation of confidentiality. The NPP should consider the volume and type of data to be handled for outsourcing. The higher the volume of sensitive data a third party manages and the more frequently it handles such data, the greater the risk that the confidentiality of that data will be compromised. Specialised IT systems used by the outsource company may not be fully integrated with plant information systems used by the NPP.

II.2.9.3. *Plan to reduce risk*

Increase the level of procedure and documentation in the IT support process. Insure high-level qualification of NPP IT staff. Select the right contractor or new hire through research and references. This research should include the investigation of key personnel. Establish long-term relation and clear interface (including transfer of knowledge) with outsourcing contractors or suppliers. Apply information security standards. Include IT training for NPP staff as to the scope of the IT support. NPPs considering outsourcing IT services should investigate whether the outsourcing company employs security measures as robust as their own. This is especially important when dealing with offshore companies run from a foreign country. While these often have impressive security protocols, a risk of one of the outsourcing company employees breaching security always exists. Since the foreign country may not have laws protecting intellectual property or other private data, businesses may find it difficult to prosecute such illegal activity. KM tools to be considered to reduce risk:

- knowledge retention - capturing the contractor's knowledge and experience in area of IT support;
- knowledge transfer/sharing - providing the contractor with access to operator's information system;
- communities of practices - establishing peer groups or joint working groups focusing on IT support issues;
- competence mapping - identifying critical competences of the contractor from the IT support point of view;
- analysis of position at risk– mapping contractor positions that could be critical from knowledge loss point of view;
- competence development - providing the training for contractor to keep competences in relevant areas of nuclear installation at required level;
- expert at risk identification – identifying the contractor’s IT experts with critical knowledge.

II.2.10. **Fire protection**

II.2.10.1. *Events and causes*

Loss of firefighting experts with nuclear knowledge (nuclear safety, operations, site layout). Unavailability of skilled firefighting workers with nuclear experience. Impaired (weakened) decision-making processes related to fire protection. Lack of capability of contractor to ensure a proper training process for its employees. Lack of capability of contractor in providing maintenance of firefighting equipment.

II.2.10.2. *Consequences*

Firefighting facilities and equipment could be out of NPP control. Failure of a contractor to meet regulatory requirements completely and in a timely manner. Decrease in fire safety of the NPP. Staffing issues may not be solved by contractor due to lack of skilled experts. Possible negative impact to emergency planning and preparedness.

II.2.10.3. *Plan to reduce risk*

Assign the NPP expert/focal point for the firefighting issues who will be responsible for knowledge transfer to/from the contractor and coordination of contractual matters. Provide the contractor with support by means of training and drill facilities on nuclear specifics. Ensure contractor conveys changes in the regulatory requirements (in area of fire safety) to the operator in advance. KM tools to be considered to reduce risk:

- knowledge transfer/sharing – providing contractors with access to documentation control system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on fire protection issues (e.g. to inform about new regulatory requirements, nuclear safety and fire protection, emergency planning and preparedness, design changes, etc.);
- competence mapping - mapping contractor positions that could be critical from knowledge loss point of view;
- competence development - providing the training for contractor to keep competences in relevant areas of nuclear installation at required level (including participation on emergency drills);
- competence building – involving the contractor into benchmarking programmes.

II.2.11. **Health and labour safety**

II.2.11.1. *Events and causes*

Loss of knowledge of specific NPP related health and labour safety (H&S) hazards and risk mitigating measures. Lack of knowledgeable plant safety personnel and poor network of safety representatives. Loss of data relating to past safety performance, incidents and accidents. Loss of environmental and individual's physical data loss of knowledge of conventional safety standards and technology.

II.2.11.2. *Consequences*

Impaired learning from experience and increased accidents and incidents. Poor quality H&S data and trending leading to lack of ability to introduce safety improvements. Poor data to support conventional H&S safety case. Wrong actions in case of real threat.

II.2.11.3. *Plan to reduce risk*

Increase the quality of H&S procedure and documentation. Training should be available for workers about basic healthcare including the assessment of symptoms and threat of irradiation. Develop and maintain a database of physical and environmental data (both historical and current) at the NPP. Access external information resources about health and labour safety such as relevant data from Chernobyl and Fukushima accidents. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of health and labour safety;
- knowledge transfer/sharing - providing contractors with access to documentation control system, design management system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on health and labour safety issues (e.g. to inform about new regulatory requirements, nuclear safety and industrial safety, emergency planning and preparedness, design changes, etc.);
- competence mapping - mapping contractor positions that could be critical from the health and labour safety point of view;
- analysis of position at risk – identifying the critical positions to ensure sustainability;
- competence development - providing the training for contractor to keep competences in relevant areas at required level (including participation on safety walkdowns);
- competence building – involving the contractor into benchmarking programmes.

II.2.12. **Waste management**

II.2.12.1. *Events and causes*

Loss of expertise in radioactive waste/spent fuel management. Jeopardizing the interfaces between operations and radioactive waste management (data exchange). Hindered access to the contractor's databases and historical date. Loss of expertise of proper risk assessment in case of outsourcing activities in several areas, such as toxicology, geochemistry, environmental engineering and meteorology. Lack of capability of contractor in providing maintenance of equipment and facilities used for radioactive waste treatment/decontamination/spent fuel storage and transportation. Jeopardizing the sensitive information due to third part involvement.

II.2.12.2. *Consequences*

Planning of radioactive waste can be adversely affected. Unavailability of qualified personnel (e.g. decontamination) can impact outage activities, jeopardizing the nuclear safety of NPP. Classified information related to the spent fuel/ radioactive waste could be out of NPP control.

II.2.12.3. *Plan to reduce risk*

Proper planning of rad waste production. Ensure relevant knowledge and information transferring during and after outage activities. Maintain and control information related to the rad waste/spent fuel at NPP including information from contractor. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of rad waste/spent fuel management;
- knowledge transfer/sharing - providing contractors with access to documentation control system, design management system, work management system, radiation protection system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on rad waste/spent fuel management issues (e.g. to inform about new regulatory requirements, internal legislation, nuclear and radiation safety, industrial safety, safeguard, outage planning, emergency planning and preparedness, design changes, etc.);
- competence mapping - mapping contractor positions that could be critical from the rad waste/spent fuel point of view;
- analysis of position at risk – identifying the critical positions to ensure sustainability;
- competence development - providing the training for contractor to maintain competences in relevant areas of nuclear installation at required level;
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the critical knowledge holders of contractors and operators with relevant expertise.

II.2.13. **Finance and accounting**

II.2.13.1. *Events and causes*

Potential errors in bookkeeping, tax administration and in economic reporting such as balance sheet, income statements or cash flow statement. Inadequate financial flows that do not meet the needs of equipment, personnel and organization. Potential errors in economic planning, poor cash flow management and related costs and problems. The deterioration of equipment due to underfunding of maintenance. Potential errors in estimating the value of fixed and movable property. Potential errors in payments. Loss of links to the financial market. Loss of financial knowledge and the ability for financial planning especially in the long-term view. Loss of knowledge about the relation of equipment with its financial needs.

II.2.13.2. *Consequences*

Growing probability of financial performance decrease and lack of necessary resources for operation and investment costs. Poor financial performance causes loss of position on the finance market like creditworthiness of customer or achieved ratings from rating agencies, which is related to significant growth of expenses of debt management or the price of insurance and that strongly influences the investment opportunities of the company and company credibility with shareholders. Errors in bookkeeping and tax administration increase the likelihood of penalties and restrictions. The risk of losing the confidence of owners and financial investors may lead to company bankruptcy.

II.2.13.3. *Plan to reduce risk*

Create a project office department directly under the CEO and employ certified project managers for strategic projects, to ensure their participation in negotiations with contractors, sub-contractors and suppliers of the project, and to guarantee a knowledge sharing culture. Apprise senior management of the risk run by trading and investment operations. Communicate financial risks to shareholders and the financial markets, leading to better pricing of debt in the market. Compare risks of activities in diverse markets. Adjust performance measures for risk. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in the area of finance and accounting;
- knowledge transfer/sharing - providing contractors with access to documentation control system, economical and book keeping systems, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on financial issues (e.g. to inform about new regulatory requirements, internal legislation, production and outage planning, investment programmes, etc.);
- competence development - providing the training for contractor to keep competences in relevant areas of nuclear installation at required level.

II.2.14. **Emergency planning**

II.2.14.1. *Events and causes*

Loss of knowledgeable personnel who provide and manage the emergency preparedness and response arrangements. Loss of skills and knowledge of emergency teams. Loss of experience in management of emergency preparedness programme. Loss of preparedness of emergency operations facility (EOF) and/or technical support centre (TSC).

II.2.14.2. *Consequences*

Loss of knowledge and competence of emergency preparedness staff, loss of preparedness of emergency operations facility (EOF) and/or technical support centre (TSC) can lead to degradation of the emergency preparedness system. Degradation of emergency preparedness system can lead to the reduction in NPP safety and can become critical condition in emergency events. specialised emergency preparedness IT systems used by the contractor may create problems with integration with plant information systems (e.g. loss of records, data exchange).

II.2.14.3. *Plan to reduce risk*

Periodically revise the emergency preparedness programme. Ensure training of emergency team. Check emergency preparedness of staff. Organise emergency drills. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of emergency planning;
- knowledge transfer/sharing - providing contractors with access to documentation control system, corrective action programme, operational information systems, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on emergency planning (e.g. to inform about new regulatory requirements, internal legislation, organizational changes, design modifications, etc.);
- analysis of position at risk - identifying the critical positions related to emergency planning;
- competence development - providing the training (including emergency preparedness drills) for contractor to keep competences in relevant areas of nuclear installation at required level;
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the contractor’s experts with critical knowledge on emergency planning.

II.2.15. **Security**

II.2.15.1. *Events and causes*

Loss of knowledgeable managers who provide establishment of the physical site security. Loss of skills and knowledge of security staff. Loss of ability to manage security plans and procedures.

II.2.15.2. *Consequences*

Degradation of perimeter control and physical security access control can lead to degradation of the security system. Degradation of the security system can lead to reduction in NPP safety and can become critical condition in emergency events. Degradation of communication between NPP and security staff in case of emergency. Specialised Security IT systems used by the contractor can present problems with integration with plant information systems (e.g. loss of records, data exchange). Specialised security IT systems used by outsource organization can be infected by computer virus.

II.2.15.3. *Plan to reduce risk*

Together with the outsourcing company implement a procedure for checking the level of competency of security staff. Ensure strong protection of the security IT system. Regularly check the system's vulnerability. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing - providing contractors with access to documentation control system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on security issues (e.g. to inform about new regulatory requirements, internal legislation, organizational changes, design modifications, etc.);
- analysis of position at risk- identifying the critical positions related to security;
- competence development - providing the training for contractor to keep competences in relevant areas of nuclear installation at required level;
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the contractor’s experts with critical knowledge on security.

II.2.16. **Licensing/regulatory affairs**

II.2.16.1. *Events and causes*

Compliance control of licensing requirements may not be performed accurately enough or in a timely manner. The communication between the regulatory body and the NPP is not prompt and/or effective. Poor content management of regular or emergency notifications.

II.2.16.2. *Consequences*

The violation of licensing requirements and deadlines could impact safety or lead to serious financial losses. Inaccuracy of safety analysis reports and other reporting documents may cause additional reviews and inspections. Potential miscommunication between the NPP and regulatory bodies could distort the real status of the NPP and affect its reputation. Risk of properly determining and handling violations and corrective actions. Risk of degradation of the quality of safety analysis reports. Risk of losing the quality of assessment inputs for periodic safety reviews.

II.2.16.3. *Plan to reduce risk*

Check list of licensing requirements should be prepared and be available for all NPP departments and outsourcing organizations. Request OSART mission from the IAEA and/or WANO peer review mission. Implement NPP procedure for safety analysis of activities performed by outsourcing organizations. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing - providing contractors with access to documentation control system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on licensing issues (e.g. to inform about new regulatory requirements, internal legislation, outage planning, investment programmes, organizational changes, design modifications, etc.);
- analysis of position at risk- identifying critical positions related to licensing/regulatory affairs;
- competence development - providing training for contractor to keep competences in relevant areas of nuclear installation at required level;
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the contractor’s experts with critical knowledge on licensing/regulatory affairs.

II.2.17. **Radiation protection**

II.2.17.1. *Events and causes*

Improper setup of radiation control area. Radiation monitoring results cannot be verified. The control of radioactive waste storage and the adherence to radiation protection rules may not be strictly implemented. The monitoring equipment may not be calibrated correctly or may not be maintained in operational condition.

II.2.17.2. *Consequences*

Small gaps of outsourcing company performance could cause significant damages – personnel overexposure, spread of contamination, etc. Radiation conditions at the plant and surrounding environment is one of the most sensitive parameters of public outreach. Each improperly performed action or information error could lead to unpredictable negative consequences for the NPP and for the industry as a whole. Risk of mismatching of thresholds for personal dosimetry control and total accumulated body exposure. Risk of violation of ALARA principles.

II.2.17.3. *Plan to reduce risk*

Create a project office department directly under the CEO and employ certified project managers for strategic projects, to ensure their participation in negotiations with contractors, sub-contractors and suppliers of the project, and to guarantee a knowledge sharing culture. According to national radiation rules and regulations, certification of outsourced companies/contractors is required. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in the radiation protection area (radiation monitoring systems, procedures and legal requirements);
- knowledge transfer/sharing - providing contractors with access to documentation control system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on radiation protection issues (e.g. to inform about new regulatory requirements, internal legislation, outage planning, investment programmes, organizational changes, design modifications, etc.);
- analysis of position at risk- identifying the critical positions related to radiation protection;
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the contractor’s experts with critical knowledge on radiation protection.

II.2.18. **Quality management**

II.2.18.1. *Events and causes*

Loss of understanding of quality drivers and objectives of the NPP, operation, and business processes. Loss of detailed knowledge of quality policy, procedures and systems. Loss of knowledge relating to quality records, audit data, corrective actions. Loss of knowledge of up-to-date quality standards. Loss of knowledge of quality personnel network (quality representatives).

II.2.18.2. *Consequences*

Serious non-compliances leading to withdrawal of quality certification can result in potential loss of production (power generation). Considerable re-work required to maintain management system. Lack of quality management can lead to impaired “quality culture” and internal NPP understanding of quality features.

II.2.18.3. *Plan to reduce risk*

Increase the level of knowledge and training for quality policy, procedures, systems and documentation in the business processes. Implement quality assurance programme in accordance with international standards. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of quality management area (procedures and legal requirements);
- knowledge transfer/sharing - providing contractors with access to documentation control system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on quality management issues (e.g. to inform about new regulatory requirements, internal legislation, organizational changes, design modifications, etc.);
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the contractor’s experts with critical knowledge on quality management in nuclear industry.

II.2.19. **Document Management**

II.2.19.1.

Loss of knowledge in review/approval cycle for documents and data. Incompatibility of IT solutions that hinder quality and timeliness of document management activities. Incomplete or late turnover of NPP documentation and records.

II.2.19.2.

Turnaround time for document and data requests are time consuming. Lower quality of documentation due to incompatible IT solutions. Unavailability of updated documentation or utilization of out-of-date documentation could lead to serious problems during operations (even to loss of licence or an incident or accident). Misuse or inadvertent sharing of classified or proprietary information by a third party could jeopardize market situation of the NPP operator. Handover/Turnover delays or incomplete design basis information.

II.2.19.3.

Ensuring the compatibility of operator's and contractor's IT tools for document management system by unifying IT systems. Deployment of operator's IT tools for document management system by the contractors (relevant contractual provisions should be adopted). Strong control throughout all phases of documentation review and approval cycles to prevent a delay or utilization of out-of-date documentation. Data protection policy should consider risks related to possible misuse of information by a third party due to contractor involvement. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing - providing contractors with access to documentation control system, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on documentation management issues (e.g. to inform about new regulatory requirements, internal legislation, organizational changes, design modifications, etc.).

II.2.20. **Asset management (enterprise resource planning elements)**

II.2.20.1. *Events or causes*

Loss of ability to estimate future changes on the market (prices, costs, expected performance and profitability of resources) or equity and depreciation evaluation. Loss of knowledge in the area of production resources planning. Loss of capability to evaluate the lifetime of equipment and other sources. Loss of capability to work in specific areas based on knowledge gap related to asset management. Loss of experience and knowledge needed to conduct asset management planning.

II.2.20.2. *Consequences*

Incorrect utilization or deployment of resources could lead to losing the ability to manage company assets resulting in financial losses and increased operational costs. Ineffective asset management reduces the ability to protect investment and directly affects the profitability of the company. The NPP operator is not be able to evaluate the lifetime of equipment and other production/non-production resources and that could lead to business strategy errors and related finance costs or loss. Improper use of the asset due to insufficient knowledge that results in prolonged outages and decreases in equipment life.

II.2.20.3. *Plan to reduce risk*

The NPP operator should keep knowledge and competence in the asset management area by means of periodical audits of the contractor and benchmarking with relevant companies. To reinforce and support this knowledge the NPP operator should use, for example, an advisory group and consultancy companies with expertise in the area. KM tools to be considered to reduce risk include:

— knowledge transfer/sharing - providing contractors with access to documentation control system, work management system, corrective action programme, etc.;
— communities of practices - establishing peer groups or joint working groups focusing on asset management issues (e.g. to inform about new regulatory requirements, internal legislation, organizational changes, outage planning, work management, design modifications, etc.).

II.2.21. **Construction and installation**

II.2.21.1. *Events or causes*

Loss of knowledge of the nuclear supply chain. Loss of expertise and capability to build new NPPs. Loss of experts with knowledge of operating NPPs. Loss of protection of sensitive design data. Loss of data exchange channels (NPP – contractor – subcontractors). Loss of responsibility for data (data ownership issues).

II.2.21.2. *Consequences*

Deadlines and quality of the construction process could be jeopardized due to insufficient knowledge and competences of the contractor. Loss of civil engineering knowledge could lead to degradation of existing buildings/facilities. Insufficient engagement of the contractor in operator's safety culture may result in increasing the incidents and damages during construction. Staffing issues may not be solved by contractor due to lack of skilled experts. Design modification management out of NPP control.

II.2.21.3. *Plan to reduce risk*

Necessary level of knowledge and competences of the contractor should be ensured by measures, such as training of the contractor's personnel. If necessary, training facilities and instructors of the NPP operator are used. The operator should keep its own competence and knowledge in this area. Strong control of the contractor's safety culture by the NPP operator can contribute to decreasing the level of incidents and injuries on contractor's side. Responsibility for data and data ownership should be clearly defined. KM tools to be considered to reduce risk include:

- knowledge retention - capturing the contractor's knowledge and experience in area of construction and installation;
- knowledge transfer/sharing - providing contractors with access to documentation control system, corrective action programme, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on construction and installation issues (e.g. to inform about new regulatory requirements, internal legislation, outage planning, security, investment programmes, design modifications, etc.);
- competency mapping;
- analysis of position at risk- identifying the critical positions related to construction and installation;
- competency building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the contractor's experts with critical knowledge on construction and installation.

II.3. MANAGERIAL PROCESSES

II.3.1. **Business operations**

II.3.1.1. *Events or causes:*

- Loss of industry-based knowledge needed for decision-making process;
- Degradation of contractor's knowledge and expertise on business operations;
- Risk of overall strategy and management plans being made by an external organization with less long-term interest in the operator's success;
- External or contract legal assistance not being fully aware of nuclear regulation laws and codes;
- Poor decision support resulting from insufficient knowledge of the external contractor.

II.3.1.2. *Consequences*

Inadequate decision-making process can lead to safety degradation and attenuation of the organization position on the market. Improper knowledge of best practice in the industry could lead to safety issues during operation.

II.3.1.3. *Plan to reduce risk*

Periodical audits of the external organization (contractor) will help in providing an assessment of management effectiveness, identifying gaps and providing recommendations for improvement. The audits should focus on compliance of outsourced business operations practices with nuclear regulations and laws. KM tools to be considered to reduce risk:

- knowledge retention - capturing the contractor's knowledge and experience in business operations;
- knowledge transfer/sharing - involving the contractors into documentation control system, operating experience feedback programme, corrective action programme. etc.;
- communities of practices - establishing peer groups or joint working groups focusing on business operation issues (e.g. to inform about new regulatory requirements, internal requirements, outage planning, operational experience, investment programmes, design modifications. etc.);
- competence development - providing training for contractor to keep competences in relevant areas of nuclear installation at required level;
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification – identifying the contractor’s experts with critical knowledge on business operation.

II.3.2. **Human resources**

II.3.2.1. *Events or causes:*

— Risk of insufficient external organization knowledge of nuclear aspects related to outsourced activities;
— Risk of degradation of planning for knowledge management such as securing necessary experts and developing human resource training programme;
— Risk of loss of operator's knowledge of human resource issues;
— Risk of inadequate talent management and succession planning programmes;
— Risk of inefficient protection of personal data.

II.3.2.2. *Consequences*

Inadequate recruiting and succession planning leading to issues in staffing of the NPP. Improper training programmes adversely affect a level of knowledge and competence of the operational staff. Insufficient communication of human resource issues could have a negative impact on safety culture of the NPP.

II.3.2.3. *Plan to reduce risk*

Identification of critical organizational competences and knowledge and development of action plan for their achievement. Internal communication programme has to take into consideration issues of human resource planning and development. Close communication between NPP operational departments and the human resource organization. KM tools to be considered to reduce risk include:

— knowledge transfer/sharing - involving the contractors into documentation control system. etc.;
— communities of practices - establishing peer groups or joint working groups focusing on human resource issues (e.g. to inform about new regulatory requirements, internal legislation, attritions and succession planning, security, organizational culture, knowledge management programmes, training programmes. etc.);
— competence development - providing the training for contractor to keep competences in relevant areas of nuclear installation at required level;
— competence building – involving the contractor into benchmarking programmes.

II.3.3. **Strategic planning**

II.3.3.1. *Events or causes:*

- Insufficient knowledge of nuclear aspects by the external organization providing the outsourced activities;
- Loss of contractor's knowledge of NPP operator's business objectives and organizational culture;
- Degradation of communication between the NPP and contractor;
- Overall strategy plans being made by an external organization with less long-term interest in the operator's success.

II.3.3.2. *Consequences*

Short term decision making. Poor quality strategy impacts business performance and impairs the ability to achieve business goals. Potential conflict of interest (planned or inadvertent transfer of confidential strategic information) when the outsourcing organization services other clients.

II.3.3.3. *Plan to reduce risk*

Close collaboration between contractor and the NPP within working groups should increase awareness of business objectives and facilitate long term planning. The contractor should be involved into NPP business target setting processes. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing - involving the contractors into documentation control system, operational experience programme, corrective action programme. etc.;
- communities of practices - establishing peer groups or joint working groups focusing on planning issues (e.g. to inform about new regulatory requirements, market situation, internal legislation, outage planning, operational experience, investment programmes, organizational culture, design modifications. etc.);
- competence development - providing the training for contractor to keep competences in relevant areas of nuclear installation at required level.

II.3.4. **Organizational changes**

II.3.4.1. *Events or causes:*

- Applying a standard approach by the external organization without considering nuclear specifics;
- Failure to identify reasons and criteria for implementation of organizational changes by the external organization;
- Inconsistency between organization changes proposed and the mission, policy and strategic principles of the operator;
- Loss of historically accumulated managerial and technical knowledge;
- Degradation of existing internal relationships among the operator's units;
- Loss of logical and functional links in the organizational structure.

II.3.4.2. *Consequences*

Potential confusion between overall principles and objectives of the NPP and the organizational structure. Decrease of NPP personnel motivation and corporate culture. Improper organizational changes could negatively impact the capability of the NPP to meet legal requirements. Reasons and criteria for implementation of organizational changes may not be appropriately specified. The mission, policy and strategic principles of the NPP may not align with organizational changes.

II.3.4.3. *Plan to reduce risk*

Create a project management office department, directly under the CEO and employ certified project managers for strategic projects, to ensure their participation in negotiations with contractors and sub-contractors of the project, and to guarantee acknowledge sharing culture. Involve operator's managers/leads in organizational changes prepared and implemented by an external organization. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing - involving the contractors into documentation control system. etc.;
- communities of practices - establishing peer groups or joint working groups focusing on organizational changes issues (e.g. to inform about new regulatory requirements, internal legislation, human resource planning, organizational culture, knowledge management programmes, training programmes. etc.);
- competence development - providing training for contractor to keep competences in relevant areas of nuclear installation at required level;
- competence building – involving the contractor into benchmarking programmes.

II.3.5. **Knowledge management activities**

II.3.5.1. *Events or causes:*

- Loss of control over knowledge management activities and relevant expertise;
- Loss of operator's knowledge of best practice in the area of knowledge management;
- Insufficient knowledge of nuclear aspects by the external organization providing the outsourced activities;
- Negative impact on related business processes (training, human resources planning. etc.).

II.3.5.2. *Consequences*

Improper knowledge management by the contractor leads to loss of critical knowledge with adverse impact on all relevant processes, such as operation, maintenance, engineering support, etc. Loss of critical knowledge increases probability of accidents and crucial failures, related to significant increase of operational costs or loss of licenses. Loss of important knowledge increases time needed for work or causes delays on the critical paths of important activities such as outage management with related significant cost increases. Loss of organizational competence causes decreasing commitment of staff and increased attrition.

II.3.5.3. *Plan to reduce risk*

Elements of knowledge management should be implemented in all the processes of the NPP focusing on preservation of organization core competence in this area. Knowledge sharing culture should be applied within the operating organization and supported by management. Knowledge management policy should be in place in the NPP.

The NPP operator should perform audits of the contractor to verify its compliance with the best practice in knowledge management. The NPP operator should use benchmarking tools to be familiar with best practice in knowledge management. KM tools to be considered to reduce risk include:

- knowledge transfer/sharing - involving the contractors into documentation control system, etc.;
- communities of practices - establishing peer groups or joint working groups focusing on knowledge management issues (e.g. to inform about new regulatory requirements, internal legislation, human resource planning, organizational culture, training programmes, etc.);
- competence development - providing the training for contractor to keep competences in relevant areas of nuclear installation at required level;
- competence building – involving the contractor into benchmarking programmes;
- expert at risk identification.

APPENDIX III. KNOWLEDGE RISK ASSESSMENT FOR OUTSOURCING BUSINESS PROCESSES

III.1. RISK MATRIX

A risk matrix is a graphic display for visualizing and comparing risks. The idea behind the risk matrix is to distinguish various risk levels for the two main dimensions of risk, likelihood of occurrence and magnitude of impact (severity). A simple example of a risk matrix is provided in Figure 2.

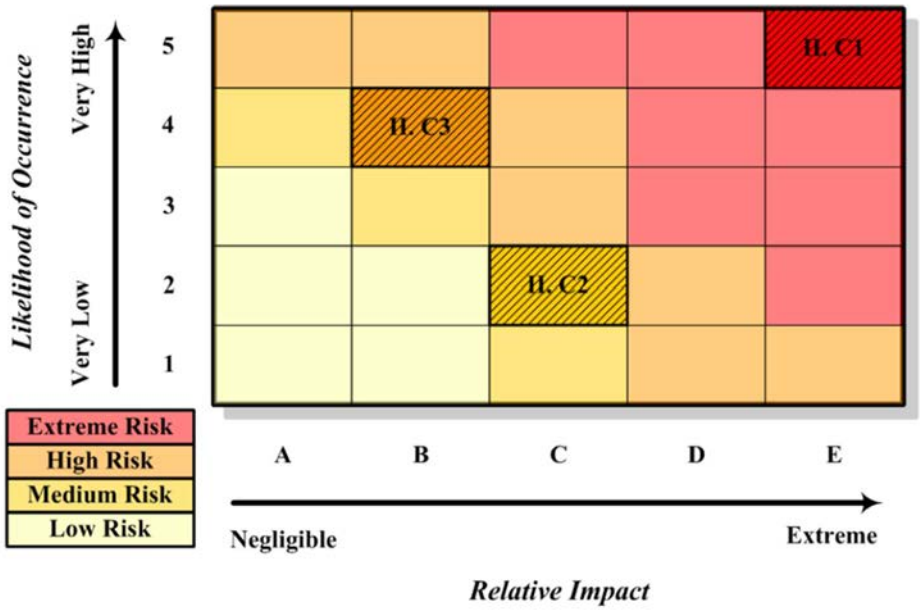

FIG. 2. Risk matrix

Each cell in the risk matrix represents a possible combination of likelihood and impact. Since the seriousness of a risk is roughly related to the product of likelihood and impact, colours (e.g. green, yellow, and red) are often used to emphasize this result. The number of rows and columns and the particular way in which they are defined (e.g. quantitatively or qualitatively) can be varied depending on the application.

The risk matrix can also be extended with risk areas and criteria for the likelihood and impact. The matrix in Figure 1 provides an example. The letters A – E corresponds with the explanation of the matrix. A risk matrix was used in the risk analyses step in the risk management process (see Table 5 and Table 6).

III.2. RISK MATRIX CHARACTERISTICS

— Impact categories:

The impact categories or risk categories should be linked to objectives. This can be the objectives of the organization or, for instance, objectives for a process. In this example the following categories are defined: nuclear safety, industrial safety, compliance, NPP availability, finance, and employee satisfaction. However, each organization should define its own relevant categories.

— Impact levels (severity):

Every impact category is divided into a number of impact levels, in this case 5. Each impact level represents a deviation from the corresponding objective. The organization decides what the intervals of each level must be. In the example, 20.000 Euro is a very small impact, and more than 10 million Euro is very large.

— Likelihood categories:

In this example there are five likelihood categories. An organization can chose any number of categories and their frequencies. After the impact level is determined the likelihood of an event with this impact is estimated.

— Risk level:

The product of the impact level and the likelihood category leads to the level of risk. In this example there are five levels, but the use four or three levels is also quite common. See Table 5.

— Response guide line:

The risk level can be used to provide guidelines for response. For this case the following guidelines are used.

TABLE 5. RISK LEVEL DESCRIPTION

Risk level	Guideline for response
Very small	No action
Small	Only action if the ALARA principle is valid
Medium	Action if costs and profits are more or less in balance
High	Take action, it can be planned
Very high	The management decide what to do

To reduce risk, the following KM tools are introduced for calculation. (See Figure 3 as example).

1) Apprenticeship
2) Best practices
3) Coaching
4) Community of practice
5) Concept mapping
6) Cross training
7) Databases/ search engine
8) Desk guides

TABLE 6. EXAMPLE OF RISK ASSESSMENT

Knowledge risk assessment for outsourcing business processes													
Business Process													
Essential knowledge													
Essential information													
Event: loss of essential knowledge /information	Possible causes	Possible consequences	KM controls in place							Other controls in place	Actual	Plan to mitigate	Residual
		(Possible degradation of process performance)	1	2	3	4	5	…	z		Risk		Risk
Lack of knowledge required for managing the business process	Availability loss of Contractor / Supplier (end of contract, bankruptcy, …..)										H/M/S		H/M/S
	Availability loss of knowledgeable people (other job, retirement, illness, ……)												
	Lack of experience in Nuclear Sector												
	Lack of experience with business process												
	Inadequate knowledge sharing (explicit and tacit)												
	Knowledge sharing not allowed (because of legal barriers, …….)												

	Miscommunication (because of language, culture, ……)												
	Responsibilities not clearly defined												
	Inadequate anticipation on changes												
	Inadequate application of KM tools (training, ……..)												
Lack of (correct) information required for managing the business process	Information not entered in information system												
	Information exchange inadequate												
	IT systems not compatible												
	Applications inadequate												
	Responsibilities not clearly defined												
	No authorisation to access information												
	Information loss (caused by IT failure, miscellaneous software, ……)												
	Information errors (because of ……)												

Note : H/M/S : high, medium, small

A	B	C
Reduced Risk factor		**17**
4. Risks in Design Management		
Description of risk	– Inaccurate data exchange can lead to the formation of erroneous design basis and subsequent incorrect design decisions. Fail of communication between NPP and designer that leads to degradation of design basis and actual design. Loss of knowledge developed by designer is resulted in design deficiencies. – Loss of design basis data, information, and knowledge. – Loss of DBI due to poorly written contract with outsourced design vendor.	
Consequences	Risk of serious d…afety and performance. Challenges in administration, finance, works schedule and staffing.	
Impact		**Probability**
Low		4
Plan to mitigate risk:	NPP and designer should create effective two – way communication to avoid loss of information (knowledge). Data are used by designer for design modification should be verified by NPP before transmission to designer to avoid low quality or erroneous decision on modification. Joint system of documents traceability and effective data review mechanism should be implemented by NPP and designer.	
NKM Tools		**Desctiption**
Select Tools:		
Risk factor		**13**
Reduced Risk factor		**13**

Impact of Risk
Select how large the impact of the risk will be.

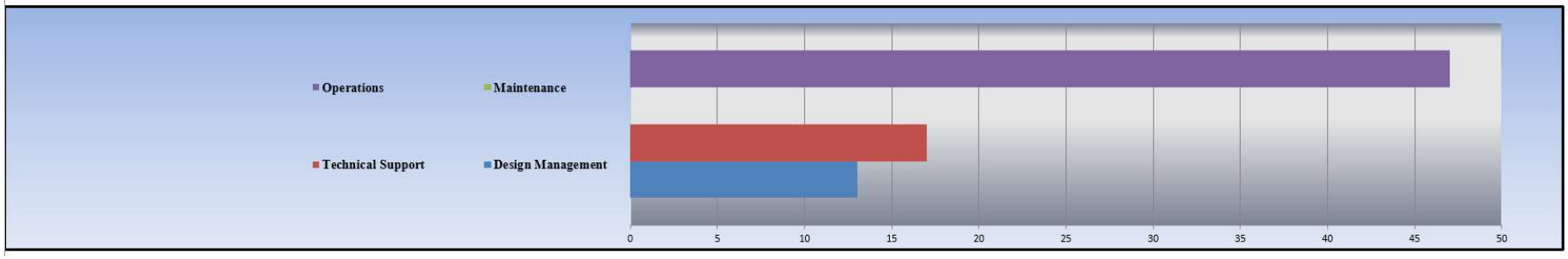

FIG.3. Example of calculation of risk factor for core process

APPENDIX IV. **CONTRACTOR COMPETENCESY REQUIREMENTS**

IV.1. BACKGROUND

Contractor personnel provide essential services to NPPs, particularly during NPP outages or for projects involving major upgrades to the NPP. In providing these services contractor personnel encounter similar problems to those that challenge NPP personnel. Accordingly, contractor personnel should be similarly competent and effectively interface with NPP personnel when performing their assigned duties. Competence is the ability to perform to identified standards; it comprises skills, knowledge and attitudes and may be developed through education, experience and training. Qualification is a formal statement of achievement, resulting from an auditable assessment; if competence is assessed, the qualification becomes a formal statement of competence and may be shown on a certificate, diploma, etc.

It is recognized that personnel are used to perform tasks that are of a specialized or temporary nature where it is not feasible to hire or maintain a full-time NPP employee. Accordingly, contractors may be used in a variety of situations to support NPPs. Typical situations include:

— Supplies and services being delivered by the contractors that are subject to different quality standards based on a graded approach to assuring quality;
— The contractors performing work on-site or off-site (see Section 3);
— Contractors involved on a short-term or long-term basis;
— Contractors involved in NPP routine activities or performing unique/specific activities;
— Contractor activities dealing with NPP safety systems or systems important for safety, which may place more demands on contractor personnel competence.

Typical services are:

— Unique services offered by specialised contractors;
— Augmentation of NPP personnel for particular tasks;
— General services provided on a permanent basis.

These services are provided by both small and large contractor organizations and require a broad range of competences. Typical examples are assessment of risk, quality assurance, compliance with procedures, communications, teamwork, work in hazardous environments and concerns about nuclear safety.

Contractor personnel should meet the qualification criteria before undertaking any activities at a NPP site, as the NPP has a responsibility for establishing qualification criteria for its own personnel and for contractor personnel.

IV.2. CONTRACTOR QUALIFICATION CRITERIA AND EXPECTED RESPONSIBILITIES

The selection of prospective service providers (contractors) should be based on an assessment of their capability to provide the required services.

Listed below are some typical criteria for selecting prospective contractors for the Invitation to bid:

— purchasing department approved suppliers list;
— technical or service capability of contractor;

— relative experience related to requisitioning task;
— work history and feedback;
— health and safety performance on previous jobs;
— availability of resources or current work load;
— ability to comply with safety and regulatory requirements;
— reputation or references background checks;
— cost competitiveness;
— individual employee records.

The respective roles and responsibilities of contractors and of NPP personnel should be clearly defined, understood and documented.

Contractor personnel should have no direct authority over NPP personnel unless this is specifically granted. NPP personnel are responsible, through their line management to the NPP manager, for making decisions after careful consideration of any specialist advice from a contractor and of other factors.

The NPP, utility or operating organization should have adequate personnel possessing the knowledge, skills and attitudes necessary to supervise and evaluate the work of contractor personnel. Personnel required to supervise contractors should be clearly identified.

Regulatory requirements in almost all Member States mandate NPP management be responsible for ensuring the competence of personnel (NPP and contract personnel) working at the NPP site and for acquiring appropriate qualifications and authorisation when required.

Based on the nature of work to be contracted out, the NPP may assign a project manager or project supervisor, whose responsibility is to assist in:

— supervising/ managing the contract within the stipulated terms and conditions;
— assessing the work based on the performance criteria established by the contract;
— communicating with the requesting department about non-performance;
— reviewing and authorising invoices for payment;
— completing contractor's performance evaluation and determining if the contractor's personnel have provided the deliverables identified in the contract.

IV.3. ENSURING CONTRACTOR PERSONNEL COMPETENCE

The principles of ensuring competence of NPP contractor personnel are derived from the overall policies of NPP quality and safety and from regulatory requirements. A key principle to ensure the competence of contractor personnel is that they should be suitably qualified before performing the work. Accordingly, contractor personnel competence should be formally assessed and documented. The final responsibility for assuring quality of all the work performed at the NPP rests with the NPP operating organization.

Assessment of contractor personnel formal qualification should be performed to ensure that any particular worker has the necessary capabilities to perform his tasks. In this concern, necessary QA procedures or guides should be developed, either by the NPP or contractor QA organization, to establish the proper technical profiles to cope with the NPP needs. Fundamentals of ensuring contractor's competence are listed below:

IV.3.1. **NPP quality assurance programme**

The NPP quality assurance programme should include formal procedures and rules to determine qualification requirements for any job that can potentially influence the quality of the work to be performed by contractors or safety personnel at the NPP. These requirements

include the needed competences (through education, experience, initial and continuing training programmes) and the qualification records.

As a key point into the QA programme, contractors' personnel competence should be assessed through verification of existing or requested documentation and records such as: certificates, diplomas, task reports, curricula vitae, evaluations results, reports of similar works performed in other NPPs, etc.

Specific training of contractor personnel could be considered within the provisions of the training system in use at the NPP and contractor personnel can be assessed, by the utility, in order to verify and guarantee their competence. Performance assessment and supervision such as inspections, audits, performance evaluations during or after the work can be included in the quality pan. The NPP quality assurance programme should allow a graded approach for those activities carried out by contractors which do not affect NPP safety.

IV.3.2. Contractor quality assurance programme

A quality assurance programme cites requirements for contractor personnel qualification, including initial and continuing training programmes. Both the contractor and NPP should audit the qualification of contractor personnel as stated in the quality assurance programme or in the quality plans developed for specific activities.

Records of contractor personnel qualification shall be available anytime to be compared with NPP requirements. Selection criteria should also be elaborated based on QA manual requirements in order to guide personnel recruitment processes.

IV.3.3. Feedback – lessons learned

The lessons learned determine challenges and good practices to improve contractor's personnel performance and feedback to both QA programmes, taking them into consideration in the NPP requirements as well as in the contractor training programmes.

The most suitable means of assuring competence of contractor personnel change from country to country due to specific regulatory requirements and other particular aspects. Nevertheless, the assessment of formal qualification together with specific training and evaluation, in a systematic manner, is the most useful approach regarding this.

It is important to consider not only the technical competence related to each particular task to be performed on site. The final results of contractor personnel activities are also related to a proper fulfilment of site access requirements which includes information about NPP layout, emergency planning, basic health physics information, fire protection, waste treatment, quality assurance and NPP organization procedures.

If there is a gap between a needed qualification and the current qualification of a technician, the NPP organization is responsible for establishing formal ways to fulfil the requirements. This can be solved through training programmes developed by contractors and formally accepted by NPP organization or other applicable training and management tools.

IV.4. THE SPECIFICATION OF QUALIFICATION REQUIREMENTS

The requirements for qualification of contractor personnel are typically defined in terms of education, experience and training. Additional requirements, such as medical fitness and other special requirements, including licences issued by regulators and special certifications from other authorities, may be applied.

The determination of qualification requirements depends on the nature of services requested by the contractor. The following situations may occur in NPPs:

— For contractors performing usual duties (not the same as permanent NPP staff), the qualification requirements should be defined by the NPP according to the duties and tasks being performed;
— For contractors performing complex or new tasks, the NPP may not have sufficient expertise in stating all the requirements regarding contractor personnel abilities to perform these tasks. In such a case the NPP specifies the site qualification requirements, and the contractor specifies task qualification criteria and makes these available to the NPP for review (or approval);
— For contractor personnel hired to perform the duties assigned to specific NPP job positions, the qualification requirements based on those required for NPP staff should be applied. In particular, these contractor personnel should successfully pass prescribed training programmes.

In all cases it is typical for contractor personnel to receive site access, radiological control and other kinds of training when applicable. The contractor should demonstrate that its personnel are qualified to all defined standards and criteria of the specified work. The NPP should periodically assess contractor personnel qualification and, possibly, the training process of contractor personnel at all locations where this training is conducted.

IV.5. MAINTAINING CONTRACTOR PERSONNEL COMPETENCE

Once qualifications are achieved, contractor personnel are expected to perform work competently. However, contractor personnel should not only initially achieve the necessary qualifications, they need to also maintain those qualifications over a period of time. Retraining requirements should be satisfied. The following topics should be monitored for any changes that may affect the ability of the contractor to perform competently:

— the work environment;
— procedures;
— systems modifications;
— tools and equipment;
— access requirements;
— radiation conditions or regulations;
— communications pathways;
— industrial and on-site operating experience, etc.

The performance of the contractor should be monitored. Lessons learned, such as encountered problems and good practices, may lead to further consideration of the required qualifications.

It is expected that the continuing training needs resulting from these considerations are systematically addressed to maintain the competence of contractor personnel. Experience within Member States has shown that the systematic approach to training (SAT) is the most effective method available for preparing and producing training programmes. Through its five interrelated phases of analysis, design, development, evaluation and implementation, SAT offers significant advantages in maintaining the competence of contractor and NPP personnel.

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ABBREVIATIONS

CM	Configuration management
CMS	Content management system
CoP	Communities of practice
ComEd	Illinois' Commonwealth Edison Company
EOF	Emergency operations facility
EPR	Enterprise planning resource systems
ERP	Enterprise resource planning
FRMEs	Fleet risk management engineers
HR	Human resources
INPO	Institute of Nuclear Power Operations
IMS	Integrated management systems
IT	Information technology
KLRA	Knowledge loss risk assessment
KLRM	Knowledge loss risk management
KM	Knowledge management
KPI	Key performance indicator
NKM	Nuclear knowledge management
NPP	Nuclear power plant
NRC	Nuclear Regulatory Commission
O&M	Operation and maintenance
PE	Professional engineer
PECO	Pennsylvania's Philadelphia Electric Company
PRA	Probabilistic risk assessment
QA	Quality assurance
R&D	Research and development
RM	Risk Management
SAT	Systematic approach to training
SRME	On-site risk management engineer
TSO	Technical support organization
T&RMs	Training and Reference Manuals

ANNEX I. MITIGATION OF RISKS OF OUTSOURCING USING KNOWLEDGE MANAGEMENT TOOLS CASE STUDY, SLOVENSKE ELEKTRANE, SLOVAK REPUBLIC

I-1. GENERAL INFORMATION

The joint-stock company Slovenské elektrárne (SE) was founded on the 21 January 2002 as a new entity of the estate and the legal successor of the original SE. Ownership structure of Slovenské elektrárne is the following: the Slovak Republic owns 34% (shareholder's rights are executed by the Ministry of Economy of the Slovak Republic) and the company Slovak Power Holding BV (SPH) owns 66% of Slovenské elektrárne shares.

SE is a company whose core business is production and sale of electricity. In terms of available installed capacity, it is the largest power generating company in Slovakia and one of the largest in Central and Eastern Europe. It also generates and sells heat and provides ancillary services to the power grid. In 2016, Slovenské elektrárne generated 18,981 GWh of electricity. Net electricity deliveries of Slovenské elektrárne in 2016 totalled at 17,242 GWh. As much as 90 % of electricity delivered was generated without greenhouse gas emissions – combining nuclear, hydroelectric, photovoltaic and biomass.

The company operates two nuclear power plants: Mochovce and Bohunice V2, both located in Western Slovakia and used VVER 440/V-213 reactors.

Bohunice V2 Nuclear Power Plant generates electricity in two units, which were commissioned in 1984 and 1985 respectively. The V2 power plant changed to combined generation of electricity and heat after building up the centralized heat supply system from Bohunice NPP to Trnava in 1987. Since 2002 a modernization programme amounting to 500 mil. EUR was implemented at V2 units and was completed in 2010 by power increase up to 505 MWe (gross) per unit.

Mochovce NPP also operates two units. Unit 1 supplies electricity to the power grid since the summer of 1998, and Unit 2 since the late 1999. Their gross power output was up-rated from 440 to 470 MW per each unit. Construction of Units 3 and 4 was suspended in 1992 and re-started in November 2008.

I-2. ISSUES AND CHALLENGES RELATED TO THE KNOWLEDGE/COMPETENCE LOSS RISKS OF OPERATING FACILITIES DUE TO EXTERNAL SERVICES AND OUTSOURCING

Market situation, external and internal economic aspects, political situation, change of generation and other changes in the environment have prompted many organizations in the nuclear industry to reorganize their practices (e.g. downsize, organization optimising, etc.). Outsourcing or contracting out of a business process to another party is one of the tools commonly used by the companies. The main drivers of the outsourcing are:

- the need to reduce costs or internal headcount;
- internal capacity constrained by increased market demand;
- internal service performance is not sufficient or does not meet requirements;
- ineffective use of internal capacities.

The presented study is based on the cases experienced by SE during of outsourcing of some activities such as firefighting brigade, physical protection, metrological services and decontamination works. SE is implementing or implemented the individual outsourcing models

on the case-by-case basis. Resulting from our experience with outsourcing, we can emphasize some of negatives as follows:

- degradation of services provided by contractor;
- loss of core competency or knowledge of the operator;
- inability of contractor to meet legal requirements;
- loss of knowledge about subcontractors;
- incompatibility between organizational cultures of operator and contractor;
- loss of best practice knowledge in area of outsourced services;
- negative impacts on training processes due to loss of experts.

To avoid or mitigate these negatives SE does implement proper measures to ensure maintaining sufficient competencies and knowledge of contractor personnel, for example by providing relevant training meeting the same requirements applying to the own personnel.

Contractor shall provide SE with necessary information and knowledge on outsourced activities to prevent a loss of core competency by the operator. From the other side, SE will retain critical knowledge experts capable to manage, coordinate and assess the services provided by contractor.

Capability of the contractor to meet relevant legal requirements will be verified by SE during whole period of the contract by means of audits or other contractor management tools. SE is implementing contractor management programme including regular assessment of outsourced services.

Benchmarking activities of SE are focused not only on core processes of NPPs but on other works provided by the contractors as well. This measure ensures SE relevant knowledge on best practice in outsourced areas.

I-3. OUTSOURCING MODELS

During preparation of outsourcing, SE is considering various models. Final decision depends on results of risk analyses and other relevant outputs. Risk analyses include different factors and impacts that could affect business performance and productivity of Company. In some cases, resulting from the risk analyses, an original proposal on outsourcing model and procedure has been re-evaluated and new outsourcing models were proposed.

For example, in case of outsourcing of metrological activities, an original proposal counted with transfer of overall works in this area on a contractor. Following analysis of possible contractors demonstrated that any of the candidates were not capable to provide the works in required scope. SE carried out a supplemental analysis of jobs and tasks carrying out by SE personnel and made a decision to re-organize relevant internal departments and optimize their activities. Following that some activities identified as non-core were transferred to the contractor.

As regards to the physical protection, relevant activities will be transferred to an external company who is a daughter company of SE. Thereby it will be ensured that classified matters related to the physical protection will be secured in accordance with legislation and SE requirements.

I-4. OUTSOURCED PROCESSES AND ACTIVITIES

For nuclear power plant operations, within last four years SE outsourced such activities as non-destructive testing, firefighting activities, certain part of decontamination services, metrological works and was considering outsourcing physical protection. Decisions on outsourcing were made based on benchmarking and in line with the best practice in the industry. In accordance with internal rules, every outsourcing process has been managed as a project activity including design, developing, assessing and implementing phases. Relevant risk analyses were carried out to ensure necessary effectiveness of the outsourcing process.

High level of contractor competency and skills is an important element of final efficiency of outsourcing. From this point of view, it is critical to identify correctly a scope and volume of services which could be outsourced. The contractor shall be able to provide assigned tasks and services in required quality and in time. The contractor shall have implemented training programme for employees consistent with training programme of the operator. The scope and methods of the training course and skill development activities are defined in relevant national legislation which is binding for the contractor. Additionally, the contractor has to meet special requirements of SE internal regulations regarding the qualification of the employees working in the nuclear power plants. If necessary, SE provides the contractor employees with training in specific areas using its own training facilities and instructors.

SE is implementing contractor management programme which includes procedures to manage outsourced activities by skilled SE workers and assess a quality of provided works. SE supervisors (such as foremen) are observing the contractor personnel during works and providing necessary feedback on their qualification and competency. This feedback is a part of assessment presenting a basis for contractual payments. Requirements on contractor personnel qualification and training are included in the contracts. SE uses the contractor evaluation system which enables to monitor and evaluate the services provided by the contractor on regular basis. Within the contractor management programme SE awards annually the best contractors, taking into account capability and level of knowledge of the contractor personnel.

In case of outsourcing, the principles of the contractor management programme are incorporated into the service agreement with chosen contractor. The following section describes one successful outsourcing project.

I-5. NUCLEAR KNOWLEDGE MANAGEMENT INITIATIVES RELATED TO KNOWLEDGE LOSS RISKS DUE TO OUTSOURCING

I-5.1. **Overview of nuclear knowledge management project of SE**

In November 2009 IAEA conducted an assist visit to inform a top management of the company about objectives and strategies of knowledge management. Based on the visit and results of a self-assessment survey in area of the knowledge management, management of SE decided to design and implement knowledge management process within nuclear part of the company. The kick-off meeting of KM project team has been held in March 2010.

Taking into account ageing of the staff of nuclear power plants of SE, the real risk of loss of the experts as well as low availability of ready-to-work recruits on a Slovak labour market, the project team defined the following deliverables of the KM project:

— systematic identification of critical positions;
— development and implementation of a succession planning programme for nuclear positions;

— development and implementation of knowledge transfer & retention tools and procedures;
— development of competence model for SE.

The deliverables should include procedures and tools needed to reduce the identified risks. The tools and procedures have been designed in accordance with a best practice of nuclear industry as specified in certain documents, such as Institute of Nuclear Power Operations INPO 06-004, Essential Elements of Knowledge Transfer and Retention [1], IAEA-TECDOC-1510, [2], IAEA-NG-T-6.11[3], etc. Members of the project team carried out the benchmarking visits to nuclear organizations (in the Czech Republic, USA, Hungary, Bulgaria, etc.) and participated in various international meetings dedicated to the nuclear knowledge management issues.

The project activities resulted in implementation of the above-mentioned deliverables in the relevant processes of the company. Currently all knowledge management activities are managed by internal documentation and monitored by managers.

I-5.2. **Nuclear knowledge management and other business processes in SE**

Currently, SE makes efforts to include knowledge management principles in other business processes with Company, such as human resource development, organizational development, succession planning and training. These efforts include, for example, engagement of identified critical knowledge holders into training process as instructors, use of experts in documentation update process (as a part of knowledge formalization), consideration of knowledge loss risks during organizational change planning (including evaluation of outsourcing processes), implementing a competence model for succession planning, etc.

As regards to the outsourcing, the outsourcing design phase includes the steps aimed on knowledge loss risk assessment. The steps are as follows:

— evaluation of outsourced activities and competences: this evaluation has to define if the competences to be outsourced are critical (core) or not;
— identification of knowledge loss risk in case of outsourcing;
— assessment of the outsourcing risk from the knowledge loss point of view.

To assess the knowledge loss risk due to outsourcing, a questionnaire was developed. Typical questions are listed below:

— Do contractor personnel have a relevant competence?
— Does contractor have a training programme for relevant competence?
— Does SE have skilled experts capable to assess a competence/knowledge of the contractor?
— Are IT tools (databases, etc.) of the contractor compatible with IT tools of SE?
— Does contractor implement a succession planning for critical knowledge holders?

The list could be extended by adding new questions depending on individual case of outsourcing process. The questions facilitate to analyses the planned outsourcing taking into account knowledge loss risks and propose measures to reduce identified risks.

I-5.3. Knowledge management tools used

SE developed and implemented a competence model for nuclear operations (NPPs and Nuclear Engineering Division). The competence model includes both technical and managerial competences. The competence model provides a list of required competences and their levels for all job positions within nuclear operations. The competences of employees have been assessed based on this model. The competence model is used as a tool for succession planning, for recruiting new workers and human resource development. SE is implementing the competence model in its SAT project. The competence model is taken into account to plan organization changes including outsourcing.

The competence model is managed by means of a specially developed IT tool (web-based software application). The software application enables evaluation of competences of personnel and maintains historical data on competence development.

One of the knowledge management tools implemented in SE is a critical position assessment. This tool uses certain criteria which consider availability of workers in the labour market, level of documented procedures used by job position, length of training on the position, and impact of decisions made on safety by job position. Critical position assessment results provide an input to succession planning activities.

For knowledge retention and sharing tools, SE developed a special questionnaire to identify critical knowledge holders and retired persons which facilitate an identification and documentation of critical knowledge. Knowledge management tools developed by the knowledge management project team are used in the Company in accordance with internal procedures.

I-6. CONCLUSION AND RECOMMENDATIONS

High levels of contractor competences and skills are an important element of outsourcing. From this point of view, it is critical to correctly identify the scope and volume of services that could be outsourced. The contractor needs to be able to provide assigned tasks and services with the required quality and timeliness.

The contractor needs to implement training programmes to ensure required levels of personnel competences and knowledge in relevant areas. The programme needs to be aligned with the NPP's training programme. If necessary, the NPP will provide training support to the contractor using its own training facilities and instructors.

An effective contractor management programme needs to be in place within operating organization to ensure a sustainability of services and works provided by outsourcer. The programme needs to include contractor monitoring and assessment procedures focused on core activities of the contractor.

Knowledge sharing between operator and contractor is an important factor of stable effectiveness of outsourced services. The operator needs to maintain the competence to to effectively manage and assess contractor work.

Knowledge management approaches need to be applied to all phases of the outsourcing process (design, implementation, effectiveness assessment). These approaches help to identify knowledge loss risks and provide necessary measures/tools to reduce the identified risks.

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ANNEX II. KNOWLEDGE LOSS RISKS OF OPERATING FACILITIES DUE TO EXTERNAL SERVICES AND OUTSOURCING. CASE STUDY: KRSKO NPP, SLOVENIA

II-1. INTRODUCTION

The Krsko NPP is a textbook case for outsourcing of design, construction and even operation and maintenance work. The plant was commissioned in 1982 and operated for the first ten years in the former Yugoslavia. After the independence of Slovenia from Yugoslavia in 1991, changes began to be made in how the NPP was managed, including a new need to recognize and accommodate a more dynamic and fluid knowledge management environment. This included increased accountability for design change, mobility of staff, and assuming more control over previously outsourced functions (see Figure II-1 and Figure II-2).

The Krsko Nuclear power plant began construction in 1974, as a joint venture of two republics of the former Yugoslavia, Slovenia and Croatia. The electrical generation is split 50/50 to each country. The plant is a Pressurized Water Reactor (PWR) built by Gilbert Associates (the EPC company now known as WorleyParsons) and Westinghouse.

The plant design is a model 60 Westinghouse reactor, and provides about 40% of Slovenia's electricity demand.

The original design power rating was 630 MWe; the plant was commissioned in 1982 and achieved synchronization to the power grid in 1983. In 2001 NPP Krsko replaced the steam generators, resulting in a power uprate to 705 MWe.

The plant construction was a "turnkey" construction arrangement, meaning the design, construction and project management would be handled completely by Westinghouse and Gilbert, with almost no Slovenian or Yugoslavian technical involvement.

The agreements for building the plant with the USA involved a number of special provisions, including operating the plant as a U.S.NRC (Nuclear Regulatory Commission) "pass-through" for regulation enforcement through the state nuclear regulator of Slovenia, and fuel enrichment services to be provided and controlled by NUEXCO in the USA.

FIG. II-1. Krsko NPP

FIG. II-2. Krsko NPP location

NPP Krsko is a member of WANO and WENRA, is also a member of EPRI and associate member of the INPO, as well as having membership in other USA-based nuclear organizations and NGO's. This means the Krsko NPP, for all intents, would be run in a manner identical to a US-built plant.

In addition, until 1993 engineering services at NPP Krsko were performed entirely by Westinghouse and Gilbert, and most services for operator training and logistics were handled by Westinghouse in the USA until around 1998. For plant modifications and retrofits, such as TMI, ATWOS and other features of US-based NPP's, Gilbert Associates was in charge of all engineering design change and design management, including installation, testing and quality records.

The Krsko NPP had no engineering organization on site until 1993, and prior to this time engineering supervision of the subcontractors was performed by maintenance staff. Because of this, in the early 1990's, the NPP Krsko embarked on taking over the responsibility for engineering design changes and the maintenance of the NPP Krsko design basis, while reducing the dependence on Westinghouse and Gilbert for design control and permitting the contracting of additional contractors, sub-contractors and suppliers.

II-2. CHALLENGES

II-2.1. **General challenges and historical aspects:**

- Cultural and social changes brought about new mobility, moving away from the "job for life" model of the previous Yugoslavia;
- Economic changes since 1991 that offer staff new opportunities for job changing;
- Slovenia, as a small country, experienced problems replacing lost competences;
- Much of the knowledge capture and competence was gained and controlled through external sources and training;
- The majority of the design knowledge was held by outside suppliers due to turnkey NPP construction model;
- Large portions of outage work performed by local subcontractors and Westinghouse, AREVA;
- Gilbert/WorleyParsons (the original EPC firm for the plant) legacy staff from USA were frequently engaged for engineering or design work, creating a dependency;
- Local work was often awarded by politics as well as qualification, as Croatia was entitled by statute to a proportion of the outsourced work contracts as 50% owner of the plant. Many of these contractors had no experience in knowledge transfer;
- Operator training and qualification/requalification was performed by Westinghouse in the USA, requiring periodic travel to facilities in Pittsburgh. Krsko NPP acquired a simulator and transferred operator training to Slovenia in the late 1990's.

II-2.2. Legacy impacts

Because of the way the NPP Krsko was financed and built, along with politics controlling the location and ownership of the plant, the national approach to knowledge capture and preservation of competence had little flexibility and made several assumptions, based on the general social and cultural landscape of a socialistic, if enlightened, state.

There was little social or geographical mobility in the former Yugoslavia in the 1970's and 1980's, and it was assumed that competence developed at the plant would remain at the

plant for the life of the project. Any knowledge passed to future staff would be predictable, and planning could be made well in advance for casual mentoring and knowledge transfer.

The outsourcing model was almost entirely turnkey, with as much training and maintenance work performed by outside organizations as possible. The intention was to eventually assume more of the responsibility for plant operations inside the organization, but until the early 1990's there was no clear plan for doing this.

II-2.3. **Organizational approaches towards outsourcing**

Because of its organization, the Krsko NPP relied almost exclusively on outsourced and contract support for maintenance and engineering changes. The process of selecting and engaging contractors was based on both technical and political criteria, with much of the contracting being awarded to both Slovenian- and Croatian-based subcontractors on a strict formula for distribution equity. Many of the workers for these contractors had originally participated in the construction of the plant, so their knowledge transfer was relatively low:

— no discrete engineering organization;
— maintenance department did light engineering contractor oversight;
— refuelling outages were mostly outsourced;
— few modifications made, and outsourced when possible;
— technical Support department, but no ISEG or system engineers until 1990's;
— no technology-based system for handling documents or data.

II-3. KRSKO NPP OUTSOURCING STRATEGY

II-3.1. **Krsko NPP project progress timeline**

The types of information and knowledge from suppliers, contractors and EPC, as well as many external organizations are, to a large extent, out of the NPP Owner/Operator's direct control, and may not be as easily captured and evaluated.

Contracts and agreements with suppliers and vendors are subject to business and commercial interpretation and negotiation, which can limit the type and amount of design knowledge that may be transferred to the Owner/Operator.

The Krsko NPP was designed and constructed with relatively little involvement of the Owner, and there was not a strong interest in concepts of knowledge capture or formal design control during the time the Krsko NPP was built.

The risks of a large percentage of the NPP Krsko knowledge being in the form of tacit knowledge, were aggravated by a general culture of familiarity and no strong, recognized need to record or otherwise capture design or operating knowledge.

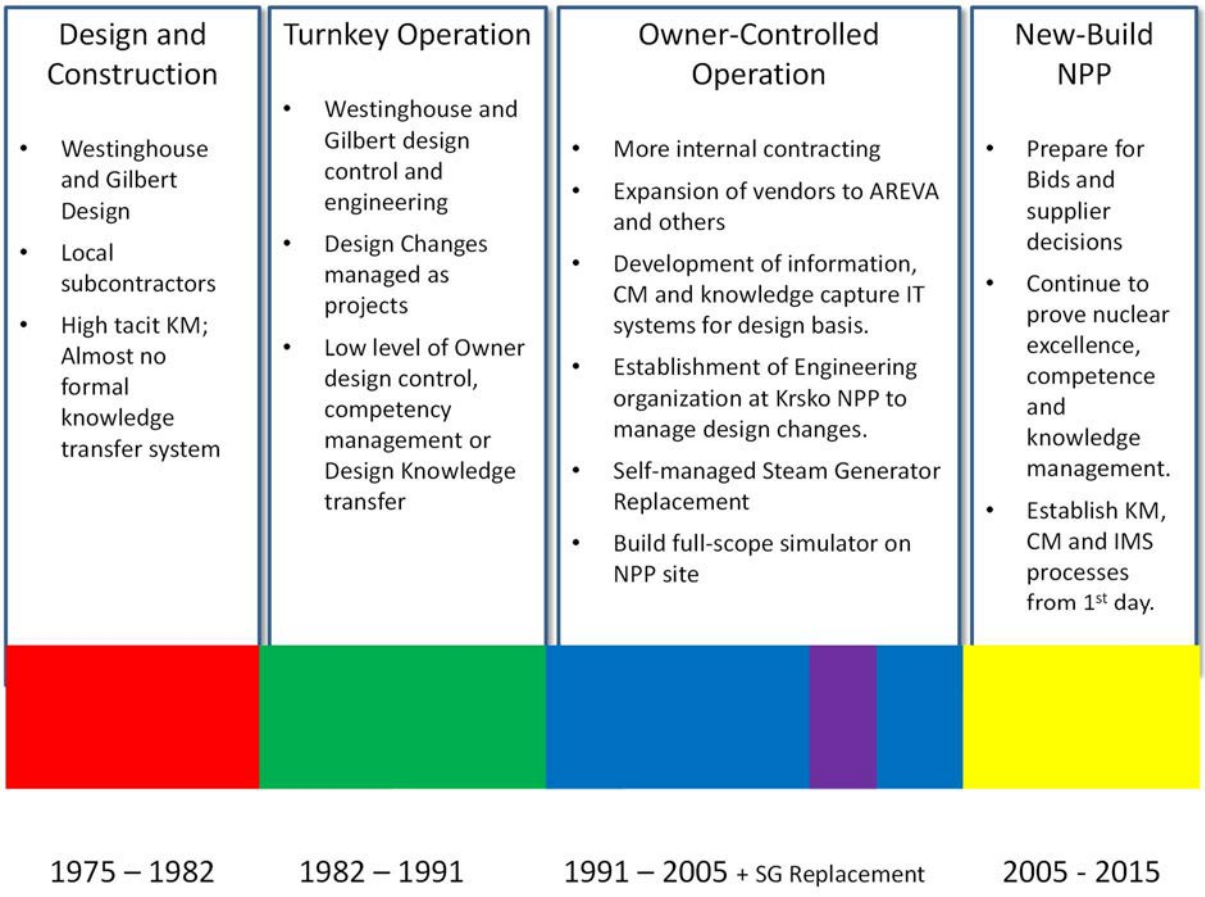

FIG.II-3. Timeline of Krsko NPP project progress.

II-3.2. **Responsibilities of stakeholders**

The principal stakeholders in the project are the governments of Slovenia and Croatia, the two plant co-owners. Secondary stakeholders include Krsko NPP management, plus third-party subcontractors involved in the maintenance and engineering modification works at the plant.

The US Government, and agencies such as NUEXCO and other fuel suppliers are tertiary stakeholders, as well as neighbouring countries sharing borders with Slovenia. With Slovenia's admission to the European Union in 2004, the EU has become a stakeholder also.

The primary stakeholders are responsible for overall safety and economic viability of the plant. In addition, they have the responsibility to their respective countries for strategic energy planning and supply, which includes their commitment to nuclear power as part of the energy supply mix. In the case of the Krsko NPP, stakeholders were bound by the requirements of managing the plant with many key elements intentionally outsourced.

An additional "stakeholder" may be viewed as the Nuclear Electric Krsko (NEK) company. Since the Krsko NPP was a "Type 1" utility, with a self-owned power plant and no parent utility company, the NEK may be viewed as a stakeholder also.

II-3.3. **Organizational competence at-risk identification**

The biggest risk for the Krsko NPP outsourcing model was, of course, loss of competence through attrition or movement of staff members. By maintaining a small NPP staff, together with the assumption of very low employee mobility or turnover, the outsourcing model fit the needs of the plant for the first ten years.

Because of the societal norms in the former Yugoslavia, large migration or turnover of staff was not expected to occur in the first 10-15 years of the plant's existence. After the changes in government in 1991, it became apparent that many of the old "rules" would be changing soon, as new opportunities appeared for talented engineers and other plant staff.

The Krsko NPP staff head count was not drastically reduced during this transition, current staffing is under 600, reduced from about 850 in the early 1990's. Most of these were reduced through attrition, re-staffing to subcontractors and retirements.

Many key staff took advantage of the new economics to leave Krsko NPP and pursue private work.

II-3.4. **Identification of services implemented through outsourcing (list of activities)**

The Krsko NPP until the late 1990's, routinely outsourced the following services:

- engineering design;
- modifications;
- operator training;
- maintenance for components;
- equipment overhaul;
- outage services;
- building services.

II-3.5. Identification of services implemented through outsourcing (list of activities)

The Krsko NPP has not planned to outsource:

- fire protection;
- housekeeping services;
- security;
- training;
- design (although some design work is supported by external TSO's).

II-4. IMPROVEMENTS AND BENEFITS

II-4.1. **NKM infrastructure and techniques**

In the 1990's, the following events facilitated improvements in NKM infrastructure and technique:

- established engineering design organization and formal design change process;
- performed design basis reconstitution – zero-timed design knowledge;
- developed KPMIS it system for CM, MRO/ERP;
- developed document control organization;

— A parent utility was formed to better manage relationships with owners (Slovenia transmission company, Croatian utility);
— Commissioned full-scope simulator; removed off-site training requirements;
— diversified from Westinghouse and WorleyParsons for external design and maintenance vendors.

II-4.2. **Succession planning**

Due to the socio-economic nature of the country, the Krsko NPP had largely taken succession planning for granted. In the 1990's and 2000's, changes were made:

— New engineering students were actively recruited and assisted in school to complete degrees;
— Mentoring programmes for new engineers and maintenance staff were established;
— Key external contract staff from service providers were offered direct employment with Krsko NPP;
— Key engineers were offered contract and outsourcing options to encourage retention;
— Retirees have been re-patriated into contract positions with the stated intent of knowledge transfer and work methods improvements;
— Key WorleyParsons staff are retained on contract in USA for consulting and knowledge transfer.

II-4.3. **Other major achievements**

— Maintenance and Outage activities were consolidated into a captive third-party contractor to control external vendors and workers and improve knowledge capture;
— Full-Scope simulator and training programme;
— Expanded internal training and qualification programmes to reduce dependence on certain types of external services and vendors;
— Improved communication and contact with "sister" Westinghouse model 60 unit operators, such as Kori 2, Kewanee, V.C. Summer and Angra NPP's;
— Refuelling outage durations fell from 35-38 days in the early 1990's to an average of 28 days now. This translates directly into €10M+ savings and generation profit;
— Improved communication with research and TSO's, such as Institute Milan Vidmar and Zagreb university engineering faculty.

II-4.4. Steam Generator replacement

The steam generator replacement project in 1997-2000 was the first major test of the improvements in organization, staff loading and knowledge management for the plant.

The replacement of the Krsko NPP steam generators in 2000, after about 18 years of power operation, was an engineering effort that rivaled construction of the original plant, in the sense that virtually every system, design basis and supporting calculation had be re-verified and/or modified as appropriate for impact analysis to the plant. It was a true test of the KPMIS and CM programme results. The new steam generators were larger and more efficient and would result in a power uprate of approximately 10%-15%.

This was on top of replacing the lost heat balance and generation through the years of plugging an increasing number of the steam generator heat-transfer tube bundles as they began to stress fracture and split open over plant life. The Westinghouse-supplied steam generators used in the Krsko NPP had a history of degraded performance and were the subject of subsequent legal action by Pressurized Water Reactor Owners Group(PWROG) member utilities.

The Krsko NPP had already plugged the regulator-approved design maximum of 18% of the total tube inventory and had requested an extension to 25% to continue operation. Plugging the tubes, while preventing migration of primary coolant inventory into the secondary steam cycle and ultimately the turbine-generator and the atmosphere, also reduced the available heat exchange surface area in the steam generators, with a corresponding loss of heat load and power.

The results were very favourable. The engineering effort took place over a period of about 18-24 months, including building the new steam generators. The steam generators were exchanged, old for new, during an extended refuelling outage that lasted 63 days, at a total project cost of about USD $120M.

The engineers, contractors and NPP Krsko management all agreed that this performance and level of success in such a short time frame would not have been possible, or even thinkable, without:

- The quality of the KPMIS, CM data and the overall KM and Design Basis Knowledge programmes at NPP Krsko;
- The Krkso NPP engineer and technician mentoring programmes had already resulted in a supply of mid-career engineers to assist in calculations, walkdowns, and design reviews;
- The System Engineer programme produced a large amount of plant condition, operating experience and status knowledge;
- The coordination of external vendors and the in-house maintenance, along with the engineering preparation, permitted the steam generators to be exchanged during an extended refuelling outage (62 days).

ANNEX III. OVERVIEW OF THE EXELON NUCLEAR RISK MANAGEMENT TEAM MODEL

III-1. EXELON RISK MANAGEMENT OUTSOURCING STRATEGY

In 2003, Exelon Nuclear decided to outsource the corporate Risk Management (Probabilistic Risk Assessment, PRA) function to a single, sole source specialty services contractor. Exelon at the time was a recently established merger of two major nuclear power plant operators with fleet operations on the east coast of the United States (Pennsylvania's Philadelphia Electric Company – PECO) and in the Midwest (Illinois' Commonwealth Edison Company - ComEd). Exelon, and innovator in consistent and cost effective operations and centralized corporate management models, was actively challenging all operational and organizational aspects of operating their nuclear fleet. Since the risk management organization was a relatively distinct part of the organization, it was considered a good candidate for exploring the benefits of a new centralized team approach via outsourcing.

Also at that time, increasing U.S. Nuclear Regulatory Commission regulatory requirements for consideration of risk in plant operations, and perceived benefit of utilizing risk-informed methods for cost savings, posed a significant challenge for staffing an adequate organization and maintaining optimal operating costs for a larger fleet. Given the increasing requirements and operational impacts, and the diverse set of skills needed to develop and maintain plant risk models, Exelon determined that having an industry leading PRA and risk management (RM) function would need to be an integral part of the company's fleet strategy. The highly specialized nature of PRA and the relatively limited number of industry resources available to support PRA and RM functions led to the realization that it would be increasingly difficult and costly to internally develop a sufficient capability in this discipline. Having the depth of support offered by the contractor allows for the availability of multiple speciality support engineers qualified and capable of providing support at all times to respond to any emergent condition, as opposed to a solely in-house structure where there may be only a single individual capable of provided the necessary specialized support. Further, the RM organization provides around-the-clock support to address emergent conditions requiring risk analyses, and having multiple qualified individuals from the contractor ensures availability of preparers and reviewers of time critical risk information.

To meet this challenge, Exelon outsourced all PRA functions to a specialty RM contractor (JENSEN HUGHES, formerly ERIN Engineering and Research Inc.) that had been a long time provider of these services to both PECO and ComEd. That arrangement has evolved over time, as experience was gained in maintaining an effective and manageable RM function and as Exelon's fleet has grown and risk-informed applications have expanded. The evolution of the corporate risk management function and the associated knowledge management and other technical, operational, and financial considerations that are the subject of this paper are examined in the sections that follow.

III-2. EVOLUTION OF THE OUTSOURCING MODEL

Although it was originally determined that a complete outsourcing arrangement could significantly enhance the efficiency of the risk management organization, within the first two years of the initial arrangement Exelon senior management became aware of the need to have some level of in-house staff knowledgeable in PRA and risk management. The nature and operational impacts of risk-informed decision making being driven by the regulator made it

necessary to have a level of Exelon management able to both oversee the outsourced organization and to be accountable for strategic planning. The need for strategic planning is especially important given the relatively long length of time needed to plan for and develop PRA models. To address this, Exelon hired back a senior risk management staff member who had been leading the outsourced function for the contractor, and made him the manager of the RM function, supported by a small in-house PRA staff. This allowed oversight of the integration of utility and contractor resources into a single organization having a large resource pool of specialized risk management personnel available to meet the planned development projects as well as able to react and provide emergent support as needed for plant issues. So, although the function was primarily outsourced and the contractor provides management and oversight of the majority of the corporate risk management staff, the function is overseen by Exelon management, who also directly manage the Exelon risk management personnel. Thus, the outsourcing arrangement evolved into a "co-sourcing" arrangement which integrates resources from Exelon and Jensen Hughes with a focus on achieving Exelon's programme objectives and operational strategy. In this manner, the Exelon nuclear fleet has access to the depth and breadth of the PRA/risk management technical expertise provided by the contractor, the contractor is able to effectively plan for and cost-effectively manage a complex programme, and both are able to focus on programme infrastructure to ensure appropriate attention to knowledge retention, development of best practices, and implementation of common approaches across the fleet.

The second major evolution of the outsourced programme occurred when Exelon acquired Constellation Energy and its three additional sites / five additional units. This resulted in an opportunity to restructure the programme to allow for reconciliation and assimilation of different risk management programme practices. As part of this restructuring, Exelon implemented a structure having a corporate risk management Director with four senior manager direct reports. Three of the senior managers are Exelon managers, while the fourth is a Jensen Hughes manager who has responsibility within the contractor for implementation of the co-sourced services. Each senior manager has a specific focus area (e.g. development of PRA models other than fire PRA; development of fire PRA models; risk informed applications; and site support), with overlap among the focus areas. Currently, the contractor manager is responsible for the site support focus area, including recruiting and training of site risk management engineers. A key focus throughout the risk management co-sourcing arrangement has been knowledge management through establishment of common practices and processes across the fleet, ensuring effective position turnover and change management, and training of Exelon staff who rely on plant risk information to perform their functions (including Operations, Work Management, Engineering and Licensing). These are discussed in the following sections.

III-2.1. **Building and maintaining an effective co-sourced risk management**

III-2.1.1. Function

There are several elements of knowledge management and related infrastructure planning that are key to the success of the Exelon risk management function.

III-2.1.2. *Development of procedures and best practices*

From the outset, a key element of the knowledge management strategy was to develop and implement a procedure and set of desktop guides (referred to as training and reference

manuals – T&RMs) and Best Practices, covering many aspects of the programme scope. Best Practices deal with specific areas regarding development of PRA models (e.g. performing data collection and analysis, human reliability analysis, developing logic models). These best practices were developed by the contractor to capture industry leading and/or state of the art specialty knowledge and are used across the fleet when updating PRA models or developing specific applications. They define innovative approaches as well as key technical information gathered from the collective knowledge of the RM Team. They are owned by Exelon and maintained as Exelon's operational goals, the regulatory environment, or industry practices change.

The risk management procedure and T&RMs address procedural steps related to performing risk informed applications (e.g. risk-informed license amendment requests, analyses supporting configuration risk management), with overlap between them. The higher level procedures outline functional roles and responsibilities as well as provide Governance and Oversight tools and processes while the job specific T&RMs define the required knowledge and combined experience for specific tasks. Taken together, these procedures, guides, and best practices guide implementation of RM tools and PRA methods in accordance with the RM team vision and strategic plan.

A key feature of the Exelon co-sourced model is that all RM team members, whether Exelon or contractor personnel, are qualified within the Exelon Learning Management System on the appropriate procedures and practices, and function as Exelon employees. As a result, no acceptance reviews are necessary as would be typical with "contractor generated" products. These aspects of the programme significantly reduce costs and also start up training when individuals shift or leave Exelon.

III-2.1.3. Stability of the RM team and change management

The makeup of the co-sourced RM team has been relatively stable since the original outsourcing in 2003 (i.e., many of the original outsourced and contractor staff who started with the programme are still serving in key roles in the programme). A key requirement of the co-sourcing arrangement is to ensure continuous coverage of the risk management function for each site. When position turnover occurs, whether due to an SRME or a PRA specialist with unique skills changing careers, leaving the company (Exelon or contractor), or otherwise becoming unavailable, replacing those individuals is typically immediate and requires no loss of site support. This is accomplished by having backup staff, in the form of fleet risk management engineers (FRMEs) who normally support two or more sites and other risk management projects, and are familiar with the site PRA models and practices, and who can step in to temporarily fill an SRME position while a replacement is found. Change management in this situation is facilitated: (a) by having the backup staff available on the risk management team; and (b) through JENSEN HUGHES maintaining, training, and managing a large on-demand talent pool of qualified specialists. This talent pool enables easy succession planning and broader knowledge transfer.

III-2.1.4. *Maintaining the level of technical expertise*

Exelon management undertook a review of the types and levels of support needed across the Exelon Fleet in 2014. Each site is supported by an on-site risk management engineer (SRME), with corporate support also provided to all of the sites. At that time the collective experience level of onsite support staff was estimated at approximately 100 years for the 10 Exelon Legacy sites (i.e., prior to the Constellation merger, with 9 contractors and 1 Exelon employee serving in SRME roles), and the collective PRA experience of all other qualified

contractor personnel that support project and infrastructure tasks was estimated to be well over 400 years. Providing this level of expertise through in-house staff, in a regulatory environment that uses PRA as a tool for enforcement, would be a significant challenge. Over time the collective PRA experience has grown with the ability to provide training and certifications to a broader group of specialized talent that can be accessed for support. This processes of maintaining expertise and bench strength is not challenged by the typical staff turnover issues facing internally staff organizations or burdened by the hiring and training process given the contractors ability to support those functions.

III-2.1.5. *Focused, coordinated planning and support*

The contractual arrangement allows a coordinated and prioritized way to develop projects and budgets. By defining a budget associated with a set of deliverables tied to a strategic plan, The RM team has greater control and focus on the task at hand which drives efficiency within the organization. In the co-sourced model, the contractor maintains interest in ensuring those tasks are properly resource loaded to ensure timely deliverables. Staffing and support over time is maintained by the contractor to ensure RM Team needs can be met. Project teams execute core infrastructure support and project tasks with allocated resources that are generally shielded from interruptions, inefficiencies associated with relying on a single individual who is multi-tasking or working to support day to day station needs. Long term partnering in the Co-Sourced model allows for long term planning and resource allocation using a centralized pool of individuals, and it provides significant efficiency in the distribution of work and growing expertise within the organization.

III-2.1.6. *Responding to changing regulatory environment and standards*

Since 2003, significant change in the use of risk information and the pedigree of documentation used to support application of PRA insights has occurred. U.S. NRC requirements for risk-informed applications and for risk-focused operational practices (e.g. configuration risk management) and the development of PRA Standards and associated regulatory expectations for meeting these standards have increased the burden of demonstrating low risk significance for plant events and for license amendments. The current pool of individuals with Exelon RM qualifications available within the co-sourced organization provides a significant advantage in understanding the changes and incorporating those changes into the site support provided by the RM programme.

III-2.1.7. *Use of individuals only when needed*

Exelon only pays for the specialized support from qualified RM Team individuals when needed. An annual budget is developed each year by the Exelon RM director, with input from the RM senior managers, including the responsible JENSEN HUGHES managers. This budget accounts for scope addressing day-to-day operating plant support, PRA model maintenance and development projects, planned risk-informed applications (e.g. risk-informed technical specifications), and an estimated allowance for emergent site support (e.g. risk evaluations of plant trips, missed equipment surveillances, and unplanned regulatory interactions). When emergent issues beyond those included in the annual plan arise, the contractor is responsible for providing qualified risk management staff to support continued plant operation with minimum impact on planned work. JENSEN HUGHES maintains a large RM staff with the full range of skills and specific expertise that would not be available within Exelon to the degree required to support the large Exelon fleet of operating plants without a correspondingly large

in-house staff. With this arrangement, additional resources with the necessary Exelon qualifications are available and can be applied whenever required, but Exelon only incurs the cost of the hours spent on the emergent work. In addition, Exelon RM resources remain focused on risk management activities rather than being diverted onto assignments that are not related to the evaluation of risk.

III-2.1.8. *Industry Support and Influence*

Many members of the Exelon risk management team, both Exelon and JENSEN HUGHES employees, also have key roles in developing industry guidance and positions on risk informed topics. The relationship between the Exelon co-sourcing and industry guidance is such that many of the processes used at Exelon have been shared with the industry. This has significant benefit in minimizing the gaps that might exist if this relationship was not present.

III-2.2. **Lessons learned and challenges**

As described in section III-2.1, the Exelon RM team was initially created to focus on achieving an organization capable of supporting Exelon's vision to be the industry leading operator of Nuclear Power Facilities. This was an ambitious and unprecedented undertaking that presented a number of challenges related to operating a large, diverse team of combined talents.

The development of a clear vision and associated strategic plan were very important in defining organizational goals and performance metrics. Development of a strategic plan to provide a blueprint for the organization became a key element of the co-sourcing arrangement. The strategic plan defines the PRA infrastructure activities (e.g. PRA model and procedure development) and staffing levels that need to be addressed over a 3–5 years planning horizon to facilitate implementation of risk-informed initiatives and evolving regulatory requirements. The plan defines key milestones and deliverables with which to measure programme success and is an important tool used by Exelon Risk Management's management team. Maintenance of the plan for use by the management team is one of the contractor's responsibilities. Definition of technical deliverables and project goals (e.g. timetables for development of Fire PRA and some external hazards PRA models in anticipation of evolving regulatory requirements) and the associated resource planning are driven by the plan. Exelon specific business goals related to cost savings, implementation of innovative approaches, increased margins, and long-term programme success are also reflected in the strategic plan and the annual resource planning to ensure the contractor fully embraces the operational challenges associated with being a partner with Exelon. Among these are activities, such as the procedures, processes, and best practices noted above, that focus on knowledge retention through standardized approaches and documentation.

Oversight over a large, combined (Exelon and contractor) organization requires appropriate management attention. At the outset of the initial fully outsourced organization the appropriate internal oversight required for success was not present. As noted in earlier in section V-2, Exelon recognized this shortcoming soon after the outsourcing and hired back a senior risk management staff member to serve as the leader of the organization, supported by a small internal staff. Over time this progressed into the "Co-sourced" model that provides both the flexibility to support the needs of the large Exelon fleet and the management structure to oversee its operation and plan for issues such as knowledge retention.

III-3. KM APPROACH

The Exelon approach to co-sourcing creates an in-house team, composed of key specialty vendor talent combined with key Exelon personnel in a co-sourced relationship as described above which attempts to mitigate the issue with an inclusive approach to partnership.

III-3.1. **Measuring organizational effectiveness**

In order to maintain continuous improvement and to ensure the RM team is meeting operational and organization goals, it is important to employ a method or a number of methods to measure organizational effectiveness. In addition to tracking and managing costs of baseline and emergent site risk management support and PRA projects, there are also benchmarking activities related to infrastructure effectiveness. These include both internal focused self-assessments and external industry benchmarking regarding programme and knowledge management practices.

The Exelon RM team utilizes a number of internal Exelon Management process and human performance tools to measure and ensure success. The combined team, regardless of employer are encouraged to utilize these tools to guide day to day work, while RM team leadership maintains a number of performance indicators and "self-assessment" tools to periodically challenge the organization.

Principles of leadership and organizational effectiveness (e.g. from INPO) are routinely highlighted for the combined team through weekly RM team interactions, as well as focused periodic training.

III-3.2. Knowledge transfer and training

The programme is managed to recognize that over time, both site and corporate risk management engineers are likely to want to move into other positions. The programme is structured to provide recruiting and training of new hires as well as cross-training of site and corporate staff to help manage the need for these transitions with minimum loss of programme knowledge.

Site risk management programme knowledge is retained through personnel turnover through the assignment of the FRME backups to each site risk management engineer. The FRME has knowledge of site processes and RM support needs, having typically been an SRME at one or more sites, and helps provide training and orientation for replacement SRMEs as the need arises. Both a formal change management process tracked within the Exelon Learning Management System and mentoring by senior contractor staff serve to ensure that appropriate qualifications and knowledge transfer are achieved.

Corporate programme knowledge is retained through mentoring and qualification of new hires, who are assigned to work with senior corporate staff on a variety of PRA development and risk applications projects for the various Exelon sites, and who are given the opportunity to interact with the SRMEs for emergent support.

III-4. SUMMARY

The Exelon RM organization is a co-sourced team consisting of internally employed management and staff combined with a broad team of JENSEN HUGHES specialty PRA and RM professionals operating as a single team with a single strategic plan using common

processes and procedures. The organization began as a completely outsourced organization which over time evolved to a co-sourced, or shared staffing model, to accommodate Exelon's evolving fleet of plants and ensure that adequate governance and oversight was in place. The organization has been extremely stable and scalable as needs and demands have changed over time, largely due to the focus on institutionalizing programme knowledge through procedures, best practices, and training. This has allowed Exelon to maintain industry leading RM organization with on demand access to a broad range of technical expertise.

The Exelon co-sourced team continues to adapt to Exelon's evolving business needs and the evolving US nuclear regulatory environment without the burden on Exelon associated with maintaining a large specialized in-house staff and the challenges of changing staffing levels to adapt to business and technical needs.

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