IAEA Nuclear Energy Series

No. NG-T-6.10

Basic Principles

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Knowledge Management and Its Implementation in Nuclear Organizations

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KNOWLEDGE MANAGEMENT AND ITS IMPLEMENTATION IN NUCLEAR ORGANIZATIONS

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The Agency's Statute was approved on 23 October 1956 by the Conference on the Statute of the IAEA held at United Nations Headquarters, New York; it entered into force on 29 July 1957. The Headquarters of the Agency are situated in Vienna. Its principal objective is "to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world''.

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FOREWORD

One of the IAEA's statutory objectives is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world." One way this objective is achieved is through the publication of a range of technical series. Two of these are the IAEA Nuclear Energy Series and the IAEA Safety Standards Series.

According to Article III.A.6 of the IAEA Statute, the safety standards establish "standards of safety for protection of health and minimization of danger to life and property". The safety standards include the Safety Fundamentals, Safety Requirements and Safety Guides. These standards are written primarily in a regulatory style and are binding on the IAEA for its own programmes. The principal users are the regulatory bodies in Member States and other national authorities.

The IAEA Nuclear Energy Series comprises reports designed to encourage and assist R&D on, and application of, nuclear energy for peaceful uses. This includes practical examples to be used by owners and operators of utilities in Member States, implementing organizations, academia, and government officials, among others. This information is presented in guides, reports on technology status and advances, and best practices for peaceful uses of nuclear energy based on inputs from international experts. The IAEA Nuclear Energy Series complements the IAEA Safety Standards Series.

The IAEA provides guidance on nuclear knowledge management and assists with the transfer and preservation of knowledge, exchange of information, establishment and support of cooperative networks, and training for the next generation of nuclear experts. Several IAEA General Conference resolutions recognize the importance of international collaboration. IAEA General Conference resolution GC(56)/RES/12, Strengthening the Agency's Activities Related to Nuclear Science, Technology and Applications, highlights the vital need to preserve and enhance nuclear knowledge management through international collaboration.

Much work has been done by the IAEA toward addressing the knowledge management needs of different nuclear organizations.This publication was developed to review the lessons learned from IAEA Knowledge Management Assist Visits that supported nuclear organizations over the period 2005–2013. Its purpose is to share best practices and experiences, and to improve the approach for future Knowledge Management Assist Visits.

The IAEA is grateful to all participants who contributed to the production of this publication. The IAEA officer responsible for this publication was Z. Pasztory of the Department of Nuclear Energy.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

The nuclear industry, similar to other highly technical industries, is knowledge based and relies heavily on the knowledge of skilled employees. The ageing workforce, declining student enrolment in science and engineering programmes, and the risk of losing accumulated knowledge and experience have drawn attention to the need for better management of nuclear knowledge. These factors have also led to a reduction in technical innovation and the potential loss of technical competences, both of which could result in reduced nuclear safety and viability, and have drawn the attention of all concerned parties to the need for effective strategies and policies for knowledge management.

Knowledge management is defined in IAEA-TECDOC-1510, Knowledge Management for Nuclear Industry Operating Organizations [1], as:

> "An integrated, systematic approach to identifying, acquiring, transforming, developing, disseminating, using, sharing, and preserving knowledge, relevant to achieving specified objectives. Knowledge management helps an organization to gain insight and understanding from its own experience. Specific activities in knowledge management help the organization to better acquire, store and utilize knowledge."

The IAEA has been actively assisting Member States to understand and achieve real benefits through the implementation of good practices in knowledge management. In 2005, the IAEA established the concept of assist visits to specifically help Member State nuclear organizations with their knowledge management issues and programmes. These visits are conducted by Knowledge Management Assist Visit (KMAV) teams, which are composed of a number of experts from different knowledge management backgrounds and organizations. These teams have been active throughout the world, and have shared experiences and provided an educational support function on the theory and practice of knowledge management.

During the initial stages of implementing the KMAV programme, the IAEA focused on the implementation of knowledge management at operating nuclear power plants (NPPs). As the value of knowledge management methods and tools became more widely recognized, the IAEA received additional requests to consider a broader application of the programme in other types of nuclear organizations such as nuclear R&D organizations and educational institutions. This publication provides feedback on the KMAV programme and highlights common issues and findings from the various organizations that have taken part in the KMAV process.

For the purpose of this publication, the term 'educational institution' includes universities and training or other education facilities, and the term 'nuclear organization' includes NPPs, R&D organizations, educational institutions, regulatory authorities, design and technical support organizations, waste processing and disposal organizations and decommissioning services organizations.

1.1. BACKGROUND

The nuclear power industry emerged from the 1950s and experienced rapid growth throughout the 1960s and 1970s. By the late 1970s, commercial NPPs were operating throughout the world and additional units were being ordered or planned.

The events of Three Mile Island, Chernobyl and Fukushima NPPs had a significant negative impact on the industry, as the use of nuclear power as a safe means to generate electricity was questioned. Other factors also played a role in the decline of the nuclear industry, including reduced growth in the demand for power, increasing costs of construction, deregulation of the power industry and competition from other electricity generation sources. The nuclear power industry experienced two decades of stagnation, from approximately 1980 until the late 1990s. During this period, the construction of numerous units was halted, orders for new units were cancelled, and, in some instances, operating units were shut down.

This stagnation had a negative impact on the workforce. The hiring of new employees slowed and experienced workers retired or left the industry. Staff downsizing contributed to the problem and also indicated a reduced confidence in nuclear power as a viable energy source. The problem was further aggravated by fewer engineering graduates selecting nuclear as a field of study or vocational goal. By the late 1990s, the ageing workforce was a challenge for most NPPs and their supporting vendors. The average age of the nuclear worker at this time was in the range of 45–55 years. Experienced workers, who had designed, constructed and were then operating NPPs, were nearing retirement and, in most cases, no recruiting efforts, pipeline training or succession planning programmes existed to hire, train and develop their replacements.

Around the turn of the century, the industry began to see a renewed interest in nuclear power. This ‘nuclear renaissance’ was driven by several factors, including the recognition of the need for a clean source of electricity with low carbon emissions, the desire for increased energy security, the economics of fossil fuels and the worldwide increased demand for electricity, especially in developing countries.

To successfully continue the safe and efficient operation of existing NPPs, and to construct new reactors, the nuclear industry requires a large, qualified workforce. All of these factors have intensified the necessity for knowledge management, including the need for continued support through programmes and services such as KMAVs.

The IAEA assists Member States by promoting the safe and efficient use of nuclear energy. Some examples of the support provided include:

- Safety standards publications;
- Operational Safety Review Team visits;
- Technical Meetings;
- The International Nuclear Information System database;
- Safeguards inspections;
- Technical reports.

The IAEA’s commitment to providing support to Member States continues through the nuclear knowledge management (NKM) and KMAV programmes.

In 2005, in response to requests from Member States, the IAEA began a new type of direct support for NPPs in the form of KMAVs. This was a natural extension to the knowledge management work that the IAEA had undertaken in previous years and was based on requests from nuclear organizations and governments that required knowledge management assistance. Some Member States were interested in establishing knowledge management programmes primarily to address the loss of knowledge and skills they were experiencing as workers retired or left the nuclear industry for other reasons.

One challenge that needed to be addressed was how to attract experienced workers, or new engineers and specialist from universities. KMAVs are designed to be a service to Member States to assist in improving or developing knowledge management programmes to address these challenges. The visits provide on-site assistance to NPP management for the development and implementation of knowledge management programmes.

The first KMAV took place at the Krško NPP in Slovenia as a joint mission between the World Association of Nuclear Operators and the IAEA in April 2005. The Krško NPP had long been concerned with workforce turnover and knowledge management retention, and had implemented programmes and technology as early as 1991 to address these issues. The mission focused on a review of the plant programmes and policies that address knowledge loss, and identified specific challenges (e.g. ageing workforce impact).

A second KMAV was requested by plant management to provide specific training and tools to assess the risk of knowledge loss and to develop corrective action plans [2]. This second KMAV also involved the use of the knowledge management assessment tool, which consisted of several key elements, each with criteria that provided a basis for an effective knowledge management programme. Conducting an assessment using this tool allows plant management to evaluate each element and determine where gaps may exist, and identify where corrective actions are needed. Since 2005, a number of KMAVs have taken place in various countries and organizations, as presented in Appendix I.

Initially, the first visits focused on requests received from NPPs. From 2008 onwards, KMAVs have also helped other types of nuclear organizations such as R&D organizations and educational institutions (e.g. nuclear departments in universities).

The IAEA process for setting up and implementing a KMAV can be found in Ref. [3]. The objectives of a KMAV are:

— To provide assistance, education and consultation to organizations looking to benefit from the application of knowledge management good practices, strategies and techniques;

— To recognize areas where good practice in knowledge management is already providing benefits;
— To provide guidance on how to rectify identified shortcomings or to implement further activities that would derive real organizational value.

One of the main tools developed by the IAEA to help with KMAVs is the IAEA knowledge management assessment tool questionnaire that was first developed for NPPs as part of IAEA-TECDOC-1510 [1]. The questionnaire is written in a self-assessment style, but in most cases those filling out the questionnaire will require assistance from IAEA experts to correctly interpret the terminology used. Since the initial draft, the tool has been updated and is now available as a spreadsheet (see Appendix II for more details). The IAEA has also developed separate knowledge management assessment criteria for other types of nuclear organizations (see Appendix II, Section II.3 on R&D organizations and Appendix II, Section II.4 on educational institutions).

The knowledge management assessment tool takes into account anecdotal results (interviews and unwritten information), and directs the review of knowledge management processes and procedures to ensure the identification of specific points at which knowledge can be captured and reviewed (see Ref. [4]).

An end of mission report is usually produced to formally record the findings and guidance from experts when the KMAV concludes. Feedback from all KMAVs has been collected over the years for the different types of nuclear operating organizations and is generally available. This information is used in Section 4 of this publication as the basis for generic guidance for nuclear organizations requesting a KMAV.

1.2. OBJECTIVE

The objective of this publication is to share best practices and experiences based on the KMAV programme undertaken by IAEA expert teams during the period 2005–2013. These visits have involved different types of nuclear organizations. A secondary aim of this publication is to provide feedback on past KMAVs, and to provide guidance for the future development of the assessment tool(s), which will assist participating nuclear organizations with optimizing their future KMAVs.

1.3. SCOPE

This publication is intended for use in nuclear organizations. It is aligned with IAEA-TECDOC-1586, Planning and Execution of Knowledge Management Assist Missions for Nuclear Organizations [3] and other supporting material in relevant IAEA TECDOCs and reports.

The history of KMAVs described in this publication includes visits to both NPPs and other nuclear organizations during 2005–2013. All KMAVs carried out during this period are considered. The details of these visits are described and analysed in Section 4 of this publication. Based on this analysis, the expansion of KMAVs is suggested in order to develop a specific knowledge management assessment tool for technical and scientific support organizations, which would:

— Support the implementation of knowledge management based on IAEA safety standards;
— Complement the current Integrated Regulatory Review Service and Operational Safety Review Team missions in the area of knowledge management;
— Support the capacity building initiatives of Member States.

It is not within the scope of this publication to make comments on the performance of individual organizations or to identify strong or weak areas of individual organizations' knowledge management. Specific inputs (including proprietary systems, processes and techniques) are not made available in this publication, and, wherever possible, feedback is made anonymous to protect the identity of participating nuclear organizations.

1.4. STRUCTURE

This publication is intended to be used by nuclear organizations that wish to use the IAEA's KMAV service. It provides an overview and observations from KMAVs for the years 2005–2013.

Section 2 describes the elements, criteria and observations for KMAVs done in NPPs and R&D organizations. Section 3 lays out the elements, criteria and observations for KMAVs in nuclear educational institutions. Section 4 summarizes suggestions for organizations planning to request a KMAV and also provides several hints for the future development of the KMAV process and tools used for knowledge maturity assessment. The accompanying CD-ROM contains three knowledge management assessment tools for NPPs, R&D organizations and nuclear education institutions in the form of spreadsheets. These tools are free of cost and contain detailed descriptions on their use with the possibility to modify their content according to the needs of the nuclear organization.

2. MAIN KNOWLEDGE MANAGEMENT ELEMENTS, CRITERIA AND OBSERVATIONS FROM KMAVs (NPPs AND R&D ORGANIZATIONS)

2.1. POLICY AND STRATEGY

2.1.1. Introduction

This element addresses the need for a knowledge management system to have a written policy, communication strategy, implementation strategy and identified responsibilities and accountabilities.

Policies are typically statements of intent or commitments to specific goals or desired outcomes. Strategies are the implementation plans to achieve these goals. While many nuclear organizations successfully implement specific knowledge management elements (e.g. human resource planning and documentation processes), a written policy and implementation strategy for knowledge management can enhance overall effectiveness and ensure alignment with other goals, programmes and processes.

2.1.2. Description of criteria

The key criteria to be assessed by the policy and strategy element are summarized in the list below and are detailed in Appendix II, Section II.2 and Section II.3:

- Knowledge management policy and strategy;
- Integration of the knowledge management policy;
- Communication of the knowledge management policy;
- Integration of the knowledge management policy into the management system;
- Responsibilities identified for the knowledge management strategy;
- Support for continual learning;
- Intellectual property policy;
- Security policy;
- External technical services in place;
- Design rationale;
- Safety culture and knowledge management alignment.

2.1.3. Observations

The KMAVs made the following observations with respect to the way that nuclear organizations were developing a policy and strategy for knowledge management:

- There was little or no evidence of a documented knowledge management policy and strategy in those nuclear organizations visited.
- There was general awareness across senior managers of the need and value of a knowledge management policy and strategy.
- There was good awareness of the relationship between the knowledge management policy and strategy and learning processes such as training, learning from experience and continual improvement.
- A number of nuclear organizations have made efforts to introduce a documented knowledge management policy and strategy, and to integrate these within the wider management system.
- From the R&D organizations visited, there was evidence of a good understanding of how knowledge management relates to intellectual property, and the need to protect information and to apply good security controls. This is particularly important to R&D organizations where the generation of intellectual property is a core activity and indicator of successful performance.
- In a number of nuclear organizations visited, a knowledge management policy was documented and embodied in the overall organizational policy. In these cases, the terminology used for describing the need for knowledge management was rather general and closely linked with leadership and excellence.

2.2. HUMAN RESOURCE PLANNING AND PROCESSES FOR KNOWLEDGE MANAGEMENT

2.2.1. Introduction

This element addresses workforce planning, succession planning, risk assessment for critical knowledge loss and employee development plans for knowledge management.

The nuclear industry currently faces significant human resource challenges (e.g. an ageing workforce, recruitment of new workers and loss of critical knowledge). Human resource planning and processes, such as strategic workforce planning, recruitment, training and employment development, succession planning and retention initiatives, are tools to ensure that an organization maintains a qualified workforce.

2.2.2. Description of criteria

The key criteria to be assessed by the human resource planning and processes element are summarized in the list below and detailed in Appendix II:

- Workforce planning;
- Succession planning;
- Knowledge loss risk assessment;
- Exit interviews;
- Talent programme;
- Job profiles;
- Competency assurance for technicians;
- Competency assurance for scientists.

2.2.3. Observations

During the KMAVs, the following issues were identified concerning human resource planning and processes:

- All nuclear organizations voiced concerns about the ageing nuclear workforce. They clearly recognized the potential for the loss of critical knowledge as many skilled and experienced workers leave due to retirement or other attrition.
- Most NPPs have some form of workforce planning methodology in place that attempts to anticipate the ongoing work requirements and staffing changes at the plant, and takes into account the number of staff needed and the specific skills required. Job profiles, qualification and training records, and competency frameworks are often used to facilitate workforce planning and to help with personal development activities.
- NPPs, which are most commonly observed during KMAVs, generally have a good succession planning programme in place, but this is focused primarily on senior management positions. Talent development programmes are prevalent in the United States of America and in western Europe, but are generally less well developed elsewhere. The availability of skills in the nuclear landscape is often presumed or taken for granted by planners when establishing strategic plans for new or existing NPPs and facilities.
- There is good workforce planning in R&D organizations and succession planning processes exist for senior management positions. In some R&D organizations, knowledge loss risk assessments have been carried out to identify singleton experts (experts who hold special, critical knowledge). The number of singleton experts tends to be higher in R&D organizations than at NPPs and presents more of a strategic risk in terms of potential knowledge loss. In general, human resources in companies and laboratories do not fully understand the identification, care and succession of singletons and are unlikely to recognize this process. In R&D organizations, there is such a thing as being irreplaceable.
- In general, employee development programmes were not mature or did not exist. Where programmes were observed, developmental opportunities for employees were often limited to senior managers.

2.3. TRAINING AND HUMAN PERFORMANCE IMPROVEMENT

2.3.1. Introduction

This element addresses the following aspects:

- Coaching and mentoring;
- Use of a systematic approach to training;
- Simulator use;
- Computer based training (e-learning);
- Refresher training;
- Human performance improvement.

2.3.2. Description of criteria

The key criteria to be assessed by the training and human performance improvement element are summarized in the list below and detailed in Appendix II:

- Use of a systematic approach to training;
- Systematic approach to training addresses knowledge management;
- Tools to capture and transfer knowledge;
- Competences;
- Refresher training;
- Human resource improvement programmes;
- Coaching and mentoring;

— Metrics (R&D organizations and educational institutions);
— Performance appraisal (R&D organizations and educational institutions).

2.3.3. Observations

During the KMAVs, the following issues concerning training and human performance improvement were identified in the organizations visited:

— The observed NPPs are well advanced in this area and most of them adopt the principles of a systematic approach to training in accordance with IAEA guidelines. A systematic approach to training is regarded as a mainstream approach in most NPPs, so there were no significant short-falls observed. Refresher training is also well advanced.
— Computer based training is well established in the majority of NPPs and tends to make good use of multimedia and 3-D modelling simulations to assist the training process and the transfer of knowledge.
— Competence evaluation is generally carried out at NPPs on a frequent basis, although robust competency frameworks are rarely used.
— Competency management was more variable in NPPs, with some organizations not having a formal approach or only using a competency framework as a tool for improvement.
— Coaching and mentoring techniques are used at NPPs to help transfer knowledge. This is used mainly for younger, more inexperienced employees and represents a longer term approach to knowledge management, but does little to address near term intrinsic knowledge losses.
— R&D organizations have good competence development processes in place. The use of performance appraisals is widely adopted, and standardized approaches to training, such as a systematic approach to training, are used.
— Human resource improvement programmes are used in R&D organizations to bolster competence development. Competence in such organizations is easier to measure because the bulk of the staff is academic and is likely to regard information as public domain or open source. They are also more accustomed to performance measurements and knowledge sharing in the form of exams, grants and publications.
— Competency management is well advanced in R&D organizations. The only relevant improvement area here concerns the measurement of competence, that is, the metrics put in place to help to gauge and focus improvement.

2.4. DOCUMENT MANAGEMENT

2.4.1. Introduction

Document management includes systems and processes for managing documents including the creation, editing, production, storage, indexing and disposal of documents. This often refers to electronic documents and uses specific document software.

The element of document management covers the following aspects:

— Learning from operating experience;
— Work control methods;
— Error prevention;
— Document control and configuration;
— Corrective action programmes;
— Benchmarking.

2.4.2. Description of criteria

The key criteria to be assessed by the document management element are summarized in the list below and detailed in Appendix II:

— Incorporation of knowledge management methods;
— Learning from experience;
— Self-assessments;
— External benchmarking;
— Operational or other field experience feedback;
— Work team composition;
— The annual report;
— Work activity documentation;
— Technical and organizational changes;
— Irradiation facilities.

2.4.3. Observations

During the KMAVs, the following issues concerning document management were identified in the organizations that were visited:

— At all NPPs, it was observed that work activities and operational experience processes, findings and lessons learned are well documented and communicated.
— Work teams are often established and composed of staff with a range of skills and abilities to help the knowledge transfer process.
— Technical changes are usually well managed, and documentation is controlled and updated to reflect changes in plant or operational states.
— Knowledge management tools and techniques are generally not integrated into the quality management system as formally written processes. Approaches such as self-assessments for knowledge management and benchmarking are rarely used at NPPs.
— It was observed that most R&D organizations do not have knowledge management processes documented and integrated within their management systems. This includes processes that capture learning from experience, which are often poorly defined in most R&D organizations.
— Most R&D organizations do not routinely use self-assessments, benchmarking and experience feedback to improve document management.
— In some R&D organizations, work activity documentation and self-assessment practices are incorporated in the organizational Q&A process.

2.5. TECHNICAL IT SOLUTIONS

2.5.1. Introduction

This element addresses the application and integration of information strategies, systems and technologies that support knowledge management. Such information systems and technologies include databases, content and document management systems, the use of the Internet and social networking technologies, as well as a range of IT systems that support operations.

2.5.2. Description of criteria

The key criteria to be assessed by the technical IT solutions element are summarized below and detailed in Appendix II:

- IT and knowledge management strategies;
- Information management;
- Scientific information access, such as access to scientific libraries, journals and databases (citation index database, nuclear event database and research reactor event database);
- Tools to capture and transfer knowledge;
- Concept mapping;
- Collaboration tools;
- Content management;
- Knowledge repository;
- Simulation tools;
- Enterprise resource planning;
- Portals;
- Search engines;
- Yellow pages;
- Expert systems;
- Wikis and blogs.

2.5.3. Observations

The KMAVs identified the following practices with respect to the way that organizations use IT solutions that support knowledge management:

- In both NPPs and R&D organizations, there was strong evidence of good use of document and content management systems.
- Within the R&D organizations, there was extensive on-line access to scientific journals, a citation index database and nuclear event information.
- There was little evidence of adoption and integration of IT solutions in support of knowledge management within NPPs.
- There was little evidence of alignment of knowledge management and IT strategies in NPPs and R&D organizations. This was despite the valuable knowledge contained within those organization’s operational systems such as maintenance, repair and overhaul, the outcomes of consultancy meetings and enterprise resource planning.
- There was little evidence at NPPs of IT tools, such as knowledge repositories, wikis, expert systems, expert yellow pages and search engines, which are rarely used probably due to a poor understanding of how to integrate these nuclear information services into the area of electricity production.
- There was little or no evidence of organizations exploiting modern IT tools to facilitate the knowledge management process (e.g. concept mapping software).

2.6. TACIT KNOWLEDGE CAPTURE

2.6.1. Introduction

This element addresses the identification, analysis, capture and dissemination of knowledge that is critical for the organization. The focus is primarily upon tacit knowledge. The scope of this element covers the following aspects:

- Taxonomy development;
- Processes for critical knowledge identification;
- Processes for knowledge elicitation and harvesting;
- Concept mapping;
- Communities of practice;
- Coaching and mentoring.

2.6.2. Description of criteria

The key criteria to be assessed by the tacit knowledge capture element are summarized below and detailed in Appendix II:

- Critical knowledge identification;
- Elicitation interviews;
- Video capture;
- On the job training;
- Mentoring and coaching;
- Communities of practice;
- Explicit capture;
- Card sorting;
- Concept mapping;
- Process mapping;
- Story telling;
- Knowledge search and retrieval;
- Utilization of captured knowledge.

2.6.3. Observations

The KMAVs identified the following practices with respect to the way that organizations were capturing knowledge:

- There was evidence of nuclear organizations understanding the need to identify critical knowledge.
- There was, however, little or no evidence of nuclear organizations undertaking systematic capture of tacit knowledge. Techniques, such as semi-structured interviews, use of concept maps and more advanced techniques, were hardly observed at the nuclear organizations visited.
- In some R&D organizations, mentoring, coaching and knowledge mapping were a part of a routine human resource development programme. In these organizations, work succession for given positions was performed more smoothly than before the knowledge management practices were introduced.
- There appeared to be a general lack of understanding, particularly within the NPPs, with regard to tacit knowledge capture and associated techniques. This was despite the importance of this form of knowledge for a nuclear organization.

2.7. KNOWLEDGE MANAGEMENT CULTURE

2.7.1. Introduction

This element addresses the practices, behaviours and attitudes that exist within a nuclear organization that altogether demonstrate the value ascribed to knowledge and lead to a high level of knowledge sharing. Trust, openness and active collaboration are all features of a positive knowledge management culture.

2.7.2. Description of criteria

The key criteria to be assessed by the knowledge management culture element are summarized below and detailed in Appendix II:

- Promotion of knowledge transfer;
- No blame culture;
- Knowledge sharing rewards;
- Leading by example;
- Individual and team relationships.

2.7.3. Observations

The KMAVs identified a number of features with respect to the nuclear organizations' knowledge management culture:

- An attitude that supports an open, no blame culture and the uninhibited reporting of safety incidents when they occur was observed at the majority of NPPs.
- The importance of having a well developed knowledge management culture was recognized by most senior managers, but little evidence was found of such a culture being proactively cultivated.
- A high degree of knowledge sharing was identified within the R&D organizations, which aligns with the very nature of their work.
- There was no reported intent to measure current knowledge management culture within any of the organizations that were visited. Most of the organizations observed were not familiar with the methods and metrics for carrying out this kind of measurement.

2.8. EXTERNAL COLLABORATION

2.8.1. Introduction

This element addresses the activities of nuclear organizations regarding their collaboration and participation with external bodies and networks; for example, through joint research, education, conferences and communities of practice.

2.8.2. Description of criteria

The key criteria to be assessed by the external collaboration element involve activities and/or organizations as summarized below and detailed in Appendix II:

- Collaboration with higher education;
- Teaching exchange;
- Joint research projects;
- Communities of practice;

— Joint seminars;
— Links with other R&D institutions.

2.8.3. Observations

During the KMAVs, the following activities with regard to external collaboration were identified:

— R&D organizations demonstrated regular collaboration, knowledge sharing and teaching activities with universities and other higher education institutions.
— Several nuclear organizations reported being involved in collaborative activities with other national and international R&D organizations or having well established links with the nuclear industry.
— It was observed that several R&D organizations employ staff involved in higher education through both joint research and teaching activities. However, a reciprocal arrangement for higher education staff to teach at the R&D organization was rarely observed.
— Communities of practice for external collaboration with other R&D and educational institutions were not well established.

3. MAIN KNOWLEDGE MANAGEMENT ELEMENTS, CRITERIA AND OBSERVATIONS FROM KMAVs (EDUCATIONAL INSTITUTIONS)

3.1. POLICY, STRATEGY, VISION AND MISSION

3.1.1. Introduction

It is critical that an educational institution and its nuclear engineering department establish well defined and clearly stated policies that include their mission and vision, and outline the strategies to achieve them. There are a number of factors that determine these strategies that need to be defined within the national context. Each educational institution will have its role to play in order to meet national needs. The extent of the policy, strategy, vision and mission will be governed by the funding available to carry out its nuclear engineering programmes. It is, therefore, important that any educational institution have realistic goals, but at the same time, set appropriately high standards that contribute to improvements over time.

3.1.2. Description of criteria

The key criteria to be assessed by the policy, strategy, vision and mission element are summarized in the list below and detailed in Appendix II, Section II.4 for educational institutions:

— Alignment of the educational institution’s policy, strategy, vision and mission with the national policy;
— Importance of nuclear education to the overall organization;
— Programme level (e.g. undergraduate or postgraduate);
— Short, medium and long term strategies;
— Collaboration with the nuclear industry;
— International dimensions;
— Strategy for attracting and enrolling students;
— Strategy to track and maintain interaction with the alumni;
— Allocation of responsibilities;

— Communication policy;
— Knowledge management policy.

3.1.3. Observations

The KMAVs identified the following regarding the way that organizations were developing policy, strategy, vision and mission:

— A governmental energy policy that includes nuclear power in the national energy mix provides motivation for developing nuclear education and training programmes in nuclear power. To be successful, the governmental policy needs to be consistent and long term. The same approach is applicable for non-power nuclear application programmes.
— A number of organizations have a clear policy to train the next generation workforce through collaboration with different university degree programmes, professional development schools, and state and local organizations.
— The main role of many nuclear organizations is to meet national nuclear workforce needs; however, collaboration with the industry is not always at a level necessary to meet these needs.
— In addition to a university's internal scientific advisory group, a few institutions have a high level advisory committee from the global community. A committee like this is needed if a university wants to take on the responsibilities of an influential international educational entity. The advisory committee is meant to provide the overall vision and strategic steps necessary for further development of policies and strategies.
— For many universities, nuclear engineering education is new, and strategies are necessary to integrate it with the existing teaching programmes.
— Among States with young nuclear power and nuclear engineering departments, there was evidence that short, medium and long term strategies for the nuclear engineering department were not fully developed. However, States with established nuclear power and nuclear engineering departments have well established strategies for the short, medium and long term.
— In some institutions, there was no strategy in place on how to attract and retain high quality students.
— There was weak communication to the key stakeholders about the potential of nuclear related departments.
— There was little or no evidence of a documented knowledge management policy and strategy in those institutions visited.
— Senior managers were, on the whole, aware of the need and value of a knowledge management policy and strategy. Furthermore, there was good awareness of the relationship between a knowledge management strategy and education in nuclear engineering.
— From the visited institutions with extensive R&D activities, there was evidence of a good understanding of how knowledge management relates to intellectual property, the need to protect information and the need to apply good security controls.
— It was recognized that nuclear engineering departments face some challenging issues when building educational programmes, including salary levels and up to date facilities. This highlights the need for a long term strategic plan that both identifies these challenges and lays out an approach that, by working with the appropriate governmental ministries, addresses ways to overcome challenges and reach predefined goals.

3.2. CAPACITY TO DELIVER NUCLEAR ENGINEERING PROGRAMMES

3.2.1. Introduction

A key assessment criterion in the KMAVs is the capability of the nuclear organization to provide nuclear engineering programmes. In comparison to other curricula, even technical curricula, nuclear engineering is one of the more challenging and costly degrees for universities to offer. It requires highly skilled and professional teachers and facilities that often require the capacity to hold and use radioactive materials. In some cases, universities have subcritical and critical reactors.

The teaching staff must have the background and standing to teach in the field. It is normally expected that the majority of the teaching staff will hold a high level university degree, usually a PhD. It is often helpful that the teaching staff have relevant work experience as well, either in research laboratories or the nuclear power industry. Through research, scholarly activities and contributions to the field, the teaching staff should ideally be highly regarded by their peers. This contributes to the capacity of the university to provide high quality nuclear engineering programmes.

It should be noted that facilities are also important. Due to the nature of radioactivity, extra safety and security is required, which leads to additional expenses. Safety has to be an integral part of the curriculum, it also has to be incorporated into the operation of the nuclear engineering programme. The educational institutions not only need to be sufficient to convey the basic principles of the profession, but also need to be sufficiently up to date to familiarize students with current practices and replicate industrial and national research laboratory equipment.

3.2.2. Description of criteria

The key criteria to be assessed by this element are summarized in the list below and detailed in Appendix II, Section II.4:

— Staff qualification and quantity that corresponds to the needs of the nuclear engineering programme;
— Use of experimental facilities at the educational institution and in other nuclear organizations;
— Use of simulators;
— Access to library facilities;
— Availability of top quality computer facilities;
— Peer reviewed publications that support educational programmes;
— Arrangements that support knowledge sharing;
— Scholarships for students;
— Flexibility of the programme;
— Advanced tools;
— Ranking of the programme;
— Student–teacher ratio;
— Courses in foreign languages;
— Participation in R&D activities.

3.2.3. Observations

The KMAVs identified the following issues concerning capacity to deliver nuclear engineering programmes:

— Almost all of the nuclear organizations that were visited voiced concerns about ageing academic staff. They clearly recognized the potential for the loss of critical knowledge, as many skilled and experienced teachers leave mainly due to retirement.
— Some governments support certain areas of research and education by making money available via research initiatives or government departments.
— Throughout numerous individual interviews with the teaching staff, it was revealed that many universities have knowledgeable and well prepared staff, reasonable intergenerational knowledge transfer and adequate succession planning. Nevertheless, there will be a need to educate a new core of professors with current nuclear knowledge to teach and perform research. Some young professors whose research heavily depends on experiments are not fully supported financially and are not able to build a lab and continue their research.
— Some instruments and equipment are used for both class teaching and research, which limits teaching and can cause delays in delivering non-teaching project reports in a timely manner.
— Laboratories, equipment, research reactors for training and support facilities at the visited universities ranged from adequate to not sufficient. Some labs that were visited had quite modern equipment, whereas other labs would benefit from newer equipment. Modern, up to date facilities attract the best students and researchers from around the world.

- With access to reactor laboratories becoming more difficult in some countries, the creation of virtual reactor laboratories allows far greater access for students.
- A good practice that can be highlighted includes the efficient enrolment of local students into the degree programmes and then into the local industry.
- Most of the national nuclear engineering departments primarily offer courses in the local language, which is an additional obstacle for enrolling foreign students.

3.3. EDUCATIONAL CURRICULA

3.3.1. Introduction

A substantive curriculum is vital for a successful nuclear engineering programme. While there is no international standard as to the content of curricula for nuclear engineering programmes, there is substantial consensus among nuclear educators around the world of what constitutes a good quality nuclear engineering curriculum [5]. The content generally includes atomic and nuclear physics, radiation detection and measurement, reactor physics and analysis, thermal hydraulics and safety, health physics and radiation protection, fuels and materials, structural mechanics, and reactor systems and design, all supported by appropriate laboratory and computer practical work. Other associated topics are sometimes included depending on the expertise of the teaching staff. These topics increase the choice of courses for potential students by providing variations to the overall curriculum. Each country and region has its own unique format and approaches, so the topics can be adapted to fit the local needs in terms of courses, classes and contact hours with students. Variations in course delivery methods may occur, but the curricula have to represent the depth and breadth of the scientific and topical areas needed for a successful nuclear engineering programme. The courses specific to nuclear engineering need to be preceded and supported by courses in mathematics, general physics, chemistry, engineering and computing at a sufficiently high level. Experimental reactor physics is recognized as a key component of a successful nuclear engineering programme, but circumstances may prevent easy access to such a facility. With many research reactors available worldwide, the educational institution without such a reactor should endeavour to ensure access to a suitable facility at another university or research institute.

3.3.2. Description of criteria

The key criteria to be assessed by the educational curricula element are summarized in the list below and detailed in Appendix II, Section II.4:

- Course prerequisites;
- General and specific competences;
- Core courses;
- Elective courses;
- Soft competences including knowledge management;
- Impact of industry needs and requirements;
- Student feedback;
- Programme evaluation.

3.3.3. Observations

The KMAVs identified the following issues concerning educational curricula:

- It was observed that, in general, nuclear engineering programmes are well structured and documented, but require further adjustments to address the requirements of different stakeholders.
- A competence based approach to developing nuclear engineering programmes is not widely used. Often the required competences are defined in a very general manner.

— The importance of soft competencies for nuclear engineering master graduates is not fully recognized.
— Close cooperation with the nuclear industry and non-power nuclear application activities provides feedback from the industry representatives who are cooperating with the programmes and ensures continual improvement and adjustment of the programmes.
— There was some evidence that student feedback is gathered and reported, and that it contributes to the development of the programmes.
— Regarding the course prerequisites, it is problematic that students from non-nuclear engineering bachelor level programmes can obtain the required level of qualification for nuclear engineering fields by taking the core courses of the master level programme. The level of competency for these students may not be comparable to students who complete a bachelor degree under the nuclear engineering programme.
— The existing curricula could be enriched by using numerical modelling and simulations as practical training linked to experimental practices. The material developed by the IAEA for nuclear education, such as NPP simulators for training, can also be used.
— Universities may consider using real life challenges in the nuclear industry as class assignments, which may be part of students' thesis projects, thus expanding the breadth of student knowledge on the nuclear industry.

3.4. OUTCOMES OF THE PROGRAMME

3.4.1. Introduction

The best conceived programmes in any educational discipline have little value without good outcomes. Programme outcomes may be best defined as the quality and quantity of graduates, together with the impacts and contributions they make in their careers and for their employers. An effective nuclear engineering programme should ideally engage with the nuclear organizations that employ their graduates to determine the quality of the preparation of the students for a career in the industry. A well organized link with the employing organizations provides critical feedback that can lead to continual improvement of the nuclear engineering programme.

3.4.2. Description of criteria

The key criteria to be assessed by the outcomes of the programme element are summarized in the list below and detailed in Appendix II, Section II.4 for outcomes of the programme:

— Graduation rate;
— Relationship with alumni;
— Graduates in the nuclear profession;
— Industry demand;
— Link with employing organizations;
— Feedback and evaluations from graduates.

3.4.3. Observations

During the KMAVs, the following issues were identified concerning outcomes of programmes:

— In the majority of observed universities, the student failure rate is rather low and graduation rate for the courses is high.
— Generally, the outcomes of the nuclear engineering programme are quite positive. Resources, such as teachers or money, are effectively targeted and utilized. Due to the close collaboration among different universities, repetitions in developing teaching material can be avoided. In some universities, distance learning is actively used.
— The number of students who graduate from nuclear engineering programmes and then enter into the nuclear industry is substantially higher than the average number of students from other engineering programmes who go on to work in their areas of study.

- It was observed that in some universities there is no well established system of communication with alumni. The feedback and evaluations from graduates, which would contribute to continual improvement of the nuclear engineering courses and facilities, are not fully utilized.
- Feedback and evaluations from the employing nuclear organizations are used in some universities to improve the nuclear engineering programmes.
- The employment of students during their studies, such as work in university research facilities or internships within the nuclear industry, with laboratories or with nuclear organizations, strongly increases employment success after graduation.
- Educational curricula in nuclear engineering in new nuclear power States or States without nuclear power still need further coordination with other universities and with the nuclear industry. Development of a comprehensive nuclear engineering curriculum is a substantial challenge for all embarking States.

3.5. QUALITY AND ACCREDITATION

3.5.1. Introduction

Independent assessments, reviews and evaluations by nuclear organizations external to the educational institution are vital for the credibility of any academic programme, although approaches to accreditation vary widely. In some countries, a government ministry or agency carries out the accreditation. Alternatively, separate organizations, non-governmental in nature, can undertake the accreditation. The accreditation process is extremely important to ensure quality in nuclear engineering academic programmes.

3.5.2. Description of criteria

The key criteria to be assessed by the quality and accreditation element are summarized in the list below and detailed in Appendix II, Section II.4:

- Policy for quality of education;
- Systematic improvement of educational quality;
- Authority and responsibilities for quality of education;
- Accreditation process;
- Impact of accreditation.

3.5.3. Observations

The KMAVs identified the following issues concerning quality and accreditation:

- Departments implementing nuclear engineering programmes pursue policies that promote quality nuclear engineering education.
- Accreditation processes to ensure quality in nuclear engineering programmes are established and defined, although approaches to accreditation vary widely.
- In many cases, an established accreditation process is a requirement of the appropriate agency or governmental organization that regulates nuclear education.
- In some universities, the quality of the programmes was indirectly recognized by some international organizations through the funding of educational projects.
- To ensure quality in nuclear engineering education, a university may consider obtaining the accreditation for nuclear engineering courses from a foreign non-governmental organization.
- As more universities around the world begin to use the Accreditation Board for Engineering and Technology process, it would be helpful to ensure that the degrees earned from different universities are recognized internationally, especially in the new nuclear States outside of Europe and North America.

3.6. HUMAN RESOURCE POLICY

3.6.1. Introduction

Experts talk of the missing generation in the nuclear industry from approximately 1980 to 2000, when the nuclear industry did not appear to be a good career choice, and young people chose other options. This proves to be especially important in the field of nuclear engineering education. Educational institutions have the continual challenge of maintaining scientific and technical competence and expertise in the area of nuclear engineering, while at the same time revitalizing and sustaining their research and teaching capabilities in this area. Because the nuclear industry experienced a down-swing, fewer and fewer students chose nuclear engineering programmes as a course of study, and senior level teachers also moved away from the field. In some countries, the situation has become severe, as the majority of faculty members in the area of nuclear engineering education are reaching, or have reached, retirement age. For nuclear energy to have a future, it is vital to solve any potential staffing problems at educational institutions.

A well conceived human resource policy is required to identify and hire young teaching staff. The policy must also include those elements that make a career in academia attractive to young professionals with a PhD, as compared to other sectors of the nuclear industry such as research laboratories, industry or government agencies and regulators. Competitive salaries, and environments conducive to carrying out rewarding teaching, challenging research and professional development are necessary to make academic careers attractive. Universities may have to establish close links with the nuclear industry and governmental nuclear technology research institutions, and invest in laboratories, equipment or state of the art computational resources to attract, and retain, the best and brightest students.

Another component is the human resource policy for existing faculty members. There need to be good opportunities for professional development. These can include, attending conferences to present the results of research, scholarships to publish papers and interaction with peers both nationally and internationally. Some universities have a sabbatical leave policy in which staff can spend a semester or year at other locations outside the educational institution. The sabbatical experience allows staff to become familiar with the latest developments in their field and can provide other qualitative and quantitative benefits.

Whatever the approach, a well developed human resource policy is critical to the effective functioning and sustainability of quality nuclear education programmes [6–8].

3.6.2. Description of criteria

The key criteria to be assessed by the human resource policy element are summarized in the list below and detailed in Appendix II, Section II.4:

- Policy to attract and retain quality people in educational programmes;
- Performance review system;
- Visiting staff and sabbaticals;
- Succession planning;
- Competence development;
- Capturing of tacit knowledge of staff close to retirement;
- Risk assessment of knowledge loss;
- Academic staff development;
- Support staff development;
- Coaching and mentoring.

3.6.3. Observations

During the KMAVs, the following issues concerning human resource policies in nuclear education were identified:

— Overall, the current status of human resource policies and resources in nuclear engineering programmes are sufficient in developed countries to meet the requirements (e.g. high school students earn adequate qualifications for outreach programmes, and teachers with experience from the nuclear industry are teaching in universities). Human resource policies and resources in developing countries, however, is a subject of concern.
— Nuclear engineering departments need to be vigilant with regard to recruitment and retirements if they are to optimize growth potential. A strengths, weaknesses, opportunities and threats self-assessment may be appropriate to help with this issue.
— Often members of the faculty have worked in industry, research laboratories and/or government agencies before joining university nuclear engineering departments. This is also regarded as very desirable and provides a richer academic experience for the students.
— Nuclear engineering departments need to be aware that young, promising members of the faculty may leave for a better salary in the nuclear industry. More attention needs to be given to systematic career development and non-monetary motivation of the faculty.
— Some important issues representing the key elements of a human resource policy and its implementation are lacking, including:
  - Establishing a policy to attract high quality students into nuclear engineering programmes, and practices and strategies to retain students in these programmes;
  - Introducing succession planning within the nuclear engineering departments;
  - Conducting a risk assessment for the loss of experienced teaching staff;
  - Establishing a policy for recruitment, retention and career development for staff;
  - Utilizing coaching and mentoring approaches to support knowledge sharing;
  - Considering diversification, for example, offering subjects that apply to other disciplines and faculties.

3.7. NATIONAL AND INTERNATIONAL DIMENSIONS

3.7.1. Introduction

The nuclear industry is global, with international partnerships and joint ventures being established on a regular basis. Nuclear engineering education needs to reflect this by also initiating international collaboration with other nuclear engineering education programmes. Students benefit immensely from an international experience as part of their education, and the links built through international collaboration benefit both staff and students. Numerous opportunities exist to build new types of cooperation across national boundaries. Taking advantage of these opportunities needs to be encouraged as much as possible to the benefit of the programmes and students. To facilitate this, international collaboration education networks are being formed in many regions of the world. Universities carrying out nuclear engineering education should ideally have strategies and agreements regarding the international component of their programmes [6].

3.7.2. Description of criteria

The key criteria to be assessed by the national and international dimensions element are summarized in the list below and detailed in Appendix II, Section II.4:

— Educational and professional networks or forums;
— Professional (learned) associations and societies;
— National and international bodies or agencies;
— Studies at other educational institutions;

— External teaching;
— Agreements with other national or international educational institutions;
— Visiting staff from national or international organizations.

3.7.3. Observations

During the KMAVs, the following issues concerning international dimensions in nuclear education were identified:

— The visited universities are involved in different national and international educational projects, programmes, associations and networks.
— The visited nuclear engineering departments have managed to develop international cooperation with successful and sufficient results over the years (on multi or bilateral bases) and have the potential to become focal points in several areas of regional nuclear education.
— The visited universities agreed that educational networks can offer best practices in education and training. The following examples have already been established:
  • The European Nuclear Education Network Association;
  • The World Nuclear University;
  • The Asian Network for Education in Nuclear Technology;
  • The University Network of Excellence in Nuclear Engineering (Canada);
  • The Education and Training Division of the American Nuclear Society;
  • The Belgian Nuclear Higher Education Network;
  • The Nuclear Technology Education Consortium (United Kingdom).
— Means to increase the role of national and international cooperation include the following:
  • Provide opportunities for international students within the same region to participate in research, summer training sessions, summer camps and workshops or short classes;
  • Encourage new international collaboration in research (write proposals with other universities in the world);
  • Develop a cyber ‘community of knowledge’ in specific areas with other countries;
  • Share seminars with others in the region. Use video conferencing or develop cyber forums for students to present their research progress on topics of interest and use that to recruit graduate students into the programme;
  • Invite visiting staff from foreign education institutions to support the improvements of existing courses and the establishment of new courses;
  • Attract more international students and offer more distance learning for international students.

3.8. COLLABORATION WITH INDUSTRY

3.8.1. Introduction

The nuclear industry is usually the largest employer of nuclear engineering graduates, as these programmes focus on preparing students to work in the nuclear industry. The path to become a nuclear professional is usually divided into two steps: university education and industry training. Collaboration between universities and the nuclear industry is very important to ensure that these two areas fit well together. It also helps to define the expectations that the nuclear industry has of recent graduates. The university needs to determine what facility type and equipment are used in the industry and, to the extent possible, acquire any suitable comparable equipment that will improve its educational programmes. Collaboration with the industry can bring very valuable resources to universities, either in the form of donated equipment, in-kind contributions or time from industrial personnel to help with teaching and, in some cases, funding, which allows the university to make investments. Collaboration with the nuclear industry can be implemented through student internships as part of the curricula. In many cases, it is also appropriate to have an external advisory board composed of representatives from the industry who can advise on the content and structure of the programme. Nuclear engineering education programmes are well served by building in-depth, mutually beneficial collaboration with a broad range of industries. Such collaboration may also provide opportunities for teaching staff to gain industry experience [6, 7].

3.8.2. Description of criteria

The key criteria to be assessed by the collaboration with industry element are summarized in the list below and detailed in Appendix II, Section II.4:

- External advisory board;
- Internship supported by industry;
- Industry support for students;
- Support for infrastructure development;
- Joint research projects;
- Professional development supported by industry;
- Professional development for industry;
- Industry specialists in education activities;
- Membership in industrial bodies or forums.

3.8.3. Observations

The KMAVs identified the following issues concerning collaboration with industry:

- The nuclear industry does not always recognize the important role they have in supporting nuclear education. There are two common reasons put forward by the industry:
  - Industry partners sometimes consider education to be wholly the responsibility of the government;
  - The nuclear industry provides in-house training for their employed workforce and therefore do not see the value in engaging with the university sector.
- A number of advantages of close cooperation with the nuclear industry were identified:
  - Scholarships for students studying nuclear subjects motivate the best students to choose nuclear options and establish early contact between students and the industry.
  - Students can apply for an internship and get hands-on experience in the nuclear industry, possibly at an NPP, or they get assigned diploma work, which requires industry involvement.
  - Practicing professionals participate in the development and/or delivery of courses and lectures at universities, sometimes as a visiting professor, lecturer or researcher. This practice is found in several countries and has the advantage that not only explicit, but also implicit and tacit knowledge is transferred.
  - The nuclear industry sends their employees to universities to provide educational upgrades. For example, employees can attend short courses or day release courses for continual professional development or attend part time to obtain a formal qualification.
- Academic institutions sometimes resist the ‘too close’ involvement of industry, not necessarily wanting too much input on the development of curricula.
- Educational institutions can also profit from effective interaction with the industry, such as customer input to discussions on programme and course curricula, industry contact and experience for lecturers to enhance their understanding of the industry, and the development of networks that can be used to find placements for students, support for research and teaching materials and aids, among other things.
- Some of the nuclear engineering departments that were visited ensure well coordinated collaboration between educational institutions and the industry through activities, such as job fairs, internships and research projects based on real industry problems, so that graduates are well prepared for careers in the nuclear industry. Through these nuclear engineering programmes, graduating students have been successful in obtaining employment in the national labour market.
- Outside funding is extremely important for the support of research projects and students at the postgraduate level. In the organizations that were visited, members of the faculty brought in funds from a wide variety of government agencies, industry and other national and international organizations.

4. SUMMARY AND FUTURE DEVELOPMENTS

This section considers guidance aimed to provide help for nuclear organizations that are in the process of considering, or have already had, a KMAV.

4.1. SUMMARY OF OBSERVATIONS FROM THE KMAVs (2005–2013)

Figures 1 and 2 present each of the elements contained in the KMAV and the level of relative maturity that was observed across more than 20 of the nuclear organizations that were visited. The purpose of the figures is to provide an indication as to areas of potential focus and support for future KMAVs, and development guidance for the short to the medium term. At the same time, the figures may be of value to individual nuclear organizations when seeking to benchmark themselves against other organizations with respect to knowledge management.

The knowledge management assessment tool has been classified according to three elements: managerial, core and support. This classification provides an indication of where in a nuclear organization the responsibilities for driving improvement for a given topic area may reside.

Element	Policy and strategy	Human resources	Training and human performance	Document management	IT solutions	Tacit capture	Knowledge management culture
Managerial*:* Required for successful knowledge management implementation	R						R
Core: Important to successful implementation of knowledge management, may address regulatory requirements, needed to sustain knowledge management		Y	G			R	
Support: Contributes to knowledge management's successful implementation, may address specific organizational needs				G	Y		

Notes:
Red — a topic area where additional and immediate measures are required;
Yellow — a topic area where improvements are needed and an additional follow-up KMAV may be of particular value;
Green — a topic area that needs to be maintained and status monitored.

FIG. 1. Summary of KMAV observations of NPPs.

Element	Policy and strategy	Human resources	Training and human performance	Document management	IT solutions	Tacit capture	Knowledge management culture	External collabor-ation
Managerial: Required for successful knowledge management implementation	R						R	
Core: Important to successful implementation of knowledge management, may address regulatory requirements, needed to sustain knowledge management		Y	Y			R		
Support: Contributes to knowledge management's successful implementation, may address specific organizational needs				Y	Y			Y

Notes:
Red — a topic area where additional and immediate measures are required;
Yellow — a topic area where improvements are needed and additional follow-up KMAV may be of particular value.

FIG. 2. Summary of KMAV observations from R&D organizations.

4.2. FUTURE DEVELOPMENT OF THE ASSESSMENT METHODOLOGY

The KMAV methodology and processes have been used successfully for many years, but the consensus is that these can be enhanced further to take into account the latest developments of knowledge management and feedback from various sources. The following improvements are suggested.

4.2.1. Review of IAEA knowledge management assessment tools

It is suggested that the current assessment tools be inspected and further developed to take into account the latest good practices and developments in technology and other related areas. This could be achieved by considering other types of assessment tools (e.g. European Foundation for Quality Management Maturity Model, Collinson & Parcell knowledge management self-assessment, Siemens AG Knowledge Management Maturity Model, Tata Consultancy Services Limited 5iKM3 model and other similar approaches). An understanding of the content of such models and how they are used in other related high risk sectors, such as oil and gas, aerospace and process industries may give useful insights.

The IAEA needs to take full ownership of all models that are developed to ensure that configuration control and formal versioning is applied to all aspects of the development process. It needs to be clear, which tools represent the latest approved information.

It is likely that additional studies will be carried out on the constantly changing, and improving, knowledge management IT and software tool landscape, to identify and present new products to potential KMAV clients. Often these products are free or very low cost, and offer one of the few tangibles to support KMAV staff in presenting a solution. Furthermore, they can provide a take away to leave with the nuclear organization to provide a structure for starting the practical phase of their NKM programme.

Review of, and guidance for, basic IT infrastructure and general information management system based process management software would help KMAV clients to conduct procedure and process reviews, data mining, knowledge analysis and other infrastructure based NKM activities, which would help to create raw material to be incorporated into the programme.

The current approach to targeting different types of nuclear organizations is a good one, but as there are common elements that are applicable to all organizational types, the most efficient approach may be to develop a set of core knowledge management criteria and to provide supplementary criteria to address the needs of different nuclear organizations. Nuclear organizational structures to be addressed include NPPs, R&D organizations, regulatory authorities, design and technical support organizations, waste processing and disposal organizations, and decommissioning services organizations. Separating the types of nuclear organizations may require too much effort and time in consideration of the return. It may also create the impression that nuclear research facilities do not merit the same attention as NPPs.

The updated maturity models need to be made available via the IAEA web site with instructions for use. Multilanguage support for such a tool would be a useful feature; the IAEA needs to consider the most appropriate means of achieving this.

4.2.2. Review of the assessment process

The IAEA KMAV and assessment process is described in Ref. [3]. In addition to using the modified tools previously described, it is believed that improvements to the current process could be achieved in a number of areas.

For those nuclear organizations requiring a KMAV or external help from IAEA consultants, it would be beneficial if background information was provided by the organization regarding its knowledge management needs and expectations. It is suggested that a form is created for this purpose, similar to that found in Appendix II for R&D organizations, but developed further to include information such as current issues and expected benefit areas. This information would greatly help the understanding of the current situation and future needs.

Another improvement that would help in the assessment process would be the use of open questions to support self-assessment and to help determine current good knowledge management practices. For example, if a nuclear organization implemented a particular IT tool or system to support knowledge management, it should ideally include follow-up questions such as:

- Which particular system was used?
- How was the system implemented?
- How long did it take?
- How is it used?
- Who uses the tool?
- What were the main problems with implementation?
- How were these problems overcome?
- What future improvements are planned?
- What benefits have come about?

The above could be used to gain a better understanding of the effectiveness of the implementation, the issues encountered and the benefits achieved.

The development of a semi-structured questionnaire should be considered to improve upon the formal closed questions that are currently used. This questionnaire could then be introduced in future KMAVs.

4.2.3. KMAV follow-up

It is important to gain insights into the success of knowledge management that is being implemented, and it is suggested that the organization that is being visited maintain an open and continued dialogue with the IAEA. This can help to determine how the nuclear organizations have benefited from the process and what new knowledge management initiatives are ongoing that build on the initial assessment findings. This feedback will help to determine future improvements in all aspects of knowledge management assistance.

4.2.4. Post-KMAV collaboration

One final area where organizations can seek help from the IAEA and other nuclear organizations is the participation in a working group or communities of practice for all of the organizations that have taken part in KMAVs. This will help with the sharing and dissemination of material between nuclear organizations and will assist in the benchmarking of performance. Communities of practice should ideally hold biannual or annual meetings with additional on-line collaboration and a wiki based application to share reports and other relevant information.

4.2.5. A revised version of the NKM self-assessment tool

A revised version of the NKM self-assessment tool needs to be developed for other types of nuclear organizations and operating contexts (e.g. R&D/technical support organization, regulatory body, new build and decommissioning).

4.3. GUIDANCE FOR ORGANIZATIONS REQUESTING A KMAV

The following guidance applies to those organizations who have requested a first KMAV.

4.3.1. Become familiar with existing IAEA documents

Nuclear organizations need to make themselves familiar with all aspects of the IAEA KMAV process as described in Ref. [3]. It is also suggested that other IAEA supporting documents are consulted prior to the visit.

4.3.2. Understand organizational issues and likely benefit areas

It is important that participating staff have a good understanding of the issues faced by the organization and expected areas where formal knowledge management is likely to deliver benefits. Knowledge management works best when it is focused to deliver results against real organizational problems, however, not all organizational issues can be solved by knowledge management. Nuclear organizations must be aware of what can be achieved realistically, together with the timescales and resources needed for successful implementation. Although discussed during the KMAV, prior consideration of these aspects will be of great value to the IAEA experts involved in the KMAV.

4.3.3. Consider the previous assessment results and lessons learned

It is suggested that the findings presented in Section 4 of this publication be studied and considered prior to the visit. This should ideally also include a preview of the knowledge management assessment tools presented in the appendices. This will help the recipient organization to become familiar with the knowledge management assessment process and provide valuable insight into the possible outcomes of the assessment.

4.3.4. Provide a preview of current IT infrastructure

Those organizations requiring a KMAV or other assistance need to also provide a preview of their current IT infrastructure and network in basic terms to assist in providing guidance for software and other technology assistance.

4.4. GUIDANCE FOR ORGANIZATIONS THAT HAVE TAKEN PART IN KMAVs

For those nuclear organizations that have already taken part in a KMAV and that have conducted a knowledge management self-assessment, there are a number of follow-up actions that should be considered. These will help the organization to further improve its knowledge management performance and also help the IAEA to develop future knowledge management programmes to assist others.

4.4.1. Maintain contact and share experiences

Nuclear organizations are encouraged to maintain contact with the IAEA and share experiences with its knowledge management initiatives. This could be achieved using the communities of practice suggested in Section 4.2.4. It would be helpful if the organization could provide feedback on the lessons learned, benefits gained and suggested areas for improvement. All information provided will be confidential and will not be distributed without prior authorization.

4.4.2. Repeat the self-assessment

Nuclear organizations are encouraged to repeat the knowledge management self-assessment on a regular basis (once per year is suggested) to gauge progress and to help identify further areas of improvement.

Appendix I

LIST OF KMAVS FROM 2005 TO 2013

Table 1 provides a list of KMAVs from 2005 to 2013.

TABLE 1. LIST OF KMAVs AT NUCLEAR ORGANIZATIONS

Date	Location/country	Topic of the KMVA/workshop	Type of organization
5–8 Apr. 2005	Krško NPP, Slovenia	World Association of Nuclear Operators KMAV with IAEA participation to Krško NPP to develop the NKM programme	NPP
13–18 Nov. 2005	Kozloduy NPP, Bulgaria	KMAV to Kozloduy NPP	NPP
25–28 Apr. 2006	Paks NPP, Hungary	KMAV to Paks NPP on knowledge management methods and practices	NPP
25–31 Mar. 2007	Kaunas University of Technology, Lithuania	KMAV to Kaunas and Vilnius University	Educational institution
23–27 Apr. 2007	Darlington and Bruce NPP and Atomic Energy of Canada Limited, Canada	KMAV for nuclear industry operating organizations	NPP/R&D organization
1–4 Apr. 2008	Ignalina NPP, Lithuania	KMAV to Ignalina NPP, Kaunas and Vilnius	NPP
1–4 Jul. 2008	Zaporozhye NPP, Ukraine	KMAV to Zaporozhye NPP	NPP
27–30 Apr. 2009	Kozloduy NPP, Bulgaria	KMAV to provide approaches, methodology and techniques on development of assessment tools	NPP
21–25 Sep. 2009	Atomic Energy Canada Limited, Canada	KMAV on knowledge management for nuclear R&D organizations	R&D organization
2–4 Sep. 2009	University of Montenegro, Montenegro	KMAV to Montenegro	Educational institution
17–20 Nov. 2009	Slovenské elektrárne, Slovakia	KMAV	NPP/utility
27–29 Jan. 2010	National Research Nuclear University MEPhI, Russian Federation	KMAV on guidance for knowledge management at technical universities, technical departments	Educational institution
18–20 May 2010	South Ukraine NPP, Ukraine	KMAV for the nuclear power industry (with emphasis on a link between knowledge management and NPP performance)	NPP
24–26 May 2010	Metsamor NPP, Armenia	KMAV to collect data for knowledge loss risk assessment	NPP

TABLE 1. LIST OF KMAVs AT NUCLEAR ORGANIZATIONS (cont.)

12–14 Sep. 2011	Atomenergomash, Russian Federation	KMAV on methodological support in implementing nuclear knowledge risk management	R&D organization
26–28 Oct. 2011	Rivne NPP, Ukraine	KMAV for the nuclear power industry (with emphasis on a link between knowledge management and NPP performance)	NPP
10–15 Oct. 2011	Nuclear Power Institute, United States of America	KMAV on benchmarking nuclear education programmes	Educational institution
9–16 Nov. 2011	Vietnam Atomic Energy Agency, Viet Nam	KMAV to Viet Nam combined with the IAEA expert mission to assist the Vietnamese universities to review education and training programmes in nuclear power	Educational institution
8–11 Oct. 2012	Tallinn University and the University of Tartu, Estonia	KMAV on benchmarking nuclear education	Educational institution
21–25 Jan. 2013	Malaysian Nuclear Agency, Malaysia	KMAV to Malaysia	R&D/technical support organization
18–22 Feb. 2013	Chulalongkorn University, Thailand	KMAV on benchmarking nuclear education	Educational institution

Appendix II

KNOWLEDGE MANAGEMENT ASSESSMENT TOOL

II.1. INTRODUCTION

The knowledge management assessment tool is based on the IAEA knowledge management assessment methodology and was developed using a spreadsheet to help identify strengths and future development areas in the organization's overall knowledge management strategy. At present, the tool exists in three versions, which cover NPPs, R&D organizations and educational institutions. All versions are presented on the accompanying CD-ROM.

The tool consists of a number of worksheets presenting the main organizational and functional categories and key elements of NKM. For example, the tool for NPPs contains seven main worksheets covering the following:

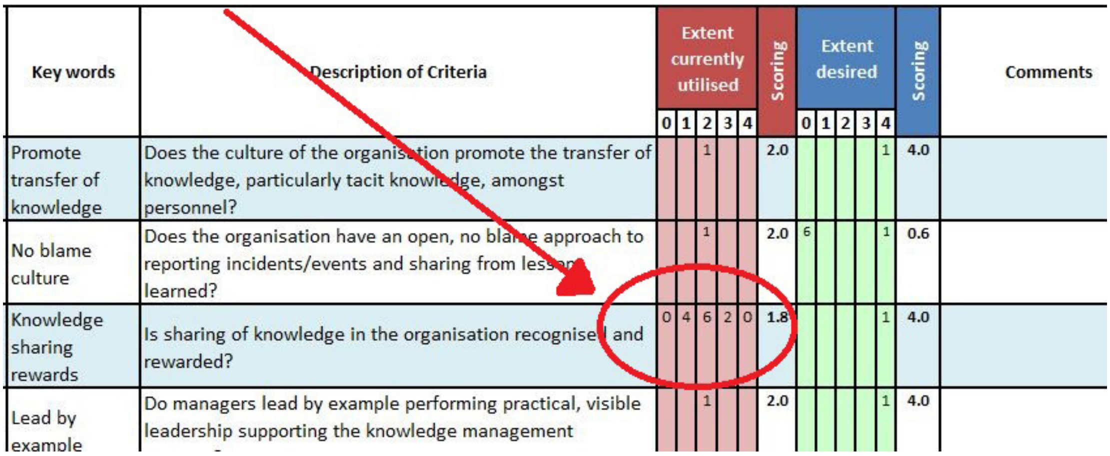
(1) Policy and strategy for knowledge management;
(2) Human resource planning and processes for knowledge management;
(3) Training and human performance improvement;
(4) Methods, procedures and documentation processes for improving knowledge management;
(5) Technical IT solutions;
(6) Approaches to capture and use tacit knowledge;
(7) Knowledge management culture and workforce culture that support knowledge management.

Each worksheet contains two columns: extent currently utilized and extent desired. Each column is broken down further into five subcolumns that contain a rating related to use as follows:

0 — not utilized at all;
1 — to a little extent;
2 — to some extent;
3 — to a great extent;
4 — to a very great extent.

Each participant of the assessment needs to assign a rating for each category and the moderator of the assessment counts the number of participants with the same rating and puts this information in the corresponding cell.

For example, the moderator is working with 12 participants who are assessing the knowledge management culture element, the knowledge sharing rewards criteria item, and the question 'Is sharing of knowledge in the organization recognized and rewarded'? During the discussion of this element, four participants rated the current status for this item as 1 (to a little extent), six participants as 2 (to some extent) and two participants as 3 (to a great extent). Zero participants rated the item as 0 (not utilized at all) or as 4 (to a very great extent). The result is shown in Fig. 3.



Key words	Description of Criteria	Extent currently utilised					Scoring	Extent desired					Scoring	Comments
		0	1	2	3	4		0	1	2	3	4		
Promote transfer of knowledge	Does the culture of the organisation promote the transfer of knowledge, particularly tacit knowledge, amongst personnel?			1			2.0					1	4.0	
No blame culture	Does the organisation have an open, no blame approach to reporting incidents/events and sharing from lessons learned?			1			2.0	6				1	0.6	
Knowledge sharing rewards	Is sharing of knowledge in the organisation recognised and rewarded?	0	4	6	2	0	1.8					1	4.0	
Lead by example	Do managers lead by example performing practical, visible leadership supporting the knowledge management			1			2.0					1	4.0	

FIG. 3. Knowledge management assessment tool rating system.

The same exercises need to be done for all items in the right (green) columns. The scoring column provides the average rating for each item and the average ratings for all items on each sheet are presented on a special diagram (see Fig. 4) at the bottom of each worksheet.

Information for each of the key elements is presented by both a summary worksheet and a corresponding diagram to give a graphical depiction of current strengths and future development areas. The tool can also generate a report and evaluation diagram.

Self-assessment can be used independently by a nuclear organization for an internal review, as a prerequisite for, or during, a KMAV. These criteria are not so much intended to provide a report card as they are to assist managers in identifying strengths to build upon and areas for improvement to be addressed in the knowledge management area.

Knowledge management assessment criteria for NPPs, R&D organizations and educational institutions are presented in tables in this appendix. For simplicity, the tables include key words and a description of criteria only. The columns for ratings and scoring are not shown.

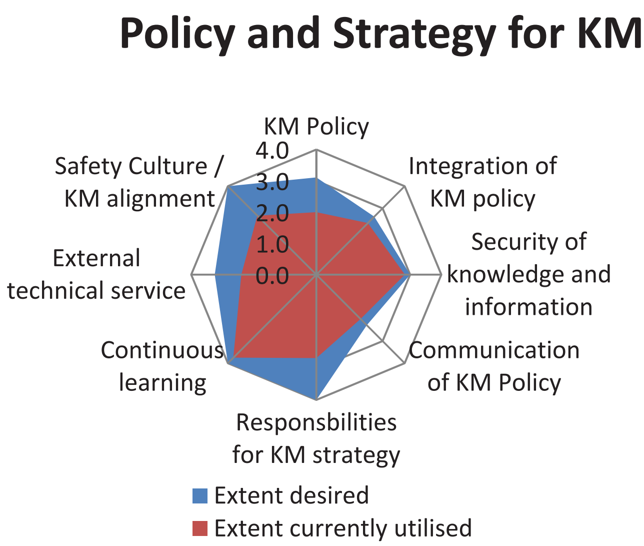


FIG. 4. Example diagram of the average ratings for all items in the policy and strategy for knowledge management element.

II.2. KNOWLEDGE MANAGEMENT ASSESSMENT CRITERIA FOR NPPs

II.2.1. Policy and strategy for knowledge management (NPPs)

This element covers the following aspects (see Table 2):

- Written policies and strategies;
- Communication strategy;
- Identification of knowledge management responsibilities.

For background information, see Refs [7, 9, 10].

TABLE 2. POLICY AND STRATEGY FOR KNOWLEDGE MANAGEMENT (NPPs)

No.	Key words	Description of criteria
1	Knowledge management policy	Does the organization have a policy for implementing its knowledge management strategy?
2	Integration of knowledge management policy	Is this knowledge management policy integrated into the management system?
3	Security of knowledge and information	Does the organization have a security policy for knowledge and information?
4	Communication of knowledge management policy	Is the knowledge management policy communicated to all staff in the organization?
5	Responsibilities for knowledge management strategy	Is there a clear identification of those responsible for formulating and implementing a knowledge management strategy in the organization?
6	Continual learning	Does the organizations' strategic focus support continual learning to improve individual and organizational performance?
7	External technical service	Does the organization have policies/processes in place to ensure that adequate responsibility for knowledge preservation is taken when supplying or relying on external technical services?
8	Safety culture/knowledge management alignment	Is the organization's knowledge management policy aligned with continued emphasis on a strong safety culture?

II.2.2. Human resource planning and processes (NPPs)

This element covers the following aspects (see Table 3):

- Workforce planning;
- Succession planning;
- Risk assessment for critical knowledge loss;
- Employee development plans for knowledge management.

For background information, see Refs [7, 11, 12].

TABLE 3. HUMAN RESOURCE PLANNING AND PROCESSES (NPPs)

No.	Key words	Description of criteria
1	Workforce planning	Does the organization implement a comprehensive workforce planning methodology to ensure that human resource needs, both current and future, are met?
2	Succession planning	Is there a succession planning programme in place?
3	Knowledge risk assessment	Are risk assessments carried out to identify potential loss of critical knowledge and skills?
4	Exit interviews	Are exit interviews carried out to capture critical knowledge and experience when people leave the organization?
5	Talent programme	Does a programme exist to develop new leadership and technical talent in a timely manner?
6	Job profiles	Does the organization utilize job profiles or the equivalent to assess and monitor its skills and competency needs?

II.2.3. Training and human performance improvement (NPPs)

This element covers the following aspects (see Table 4):

— Coaching and mentoring;
— Systematic approach to training;
— Simulator use;
— Computer based training (e-learning);
— Refresher training;
— Human performance improvement.

For background information, see Refs [13–16].

TABLE 4. TRAINING AND HUMAN PERFORMANCE IMPROVEMENT (NPPs)

No.	Key words	Description of criteria
1	Use of a systematic approach to training	Does the organization incorporate formal systematic approach to training principles into its training programmes?
2	Systematic approach to training addresses knowledge management	Does the formal systematic approach to training programme address, capture and disseminate knowledge?
3	Tools to capture/transfer knowledge	Does the training programme utilize appropriate tools, such as simulators, computer based training and multimedia simulations, to capture and transfer critical knowledge?
4	Competences	Is competence evaluated on a regular basis?
5	Refresher trainings	Is regular refresher training carried out to maintain and enhance competence?
6	Human resource improvement programmes	Does the organization have a formal human performance improvement programme to maintain and enhance competence?
7	Coaching and mentoring	Are coaching and mentoring approaches used to support knowledge sharing?

II.2.4. Document management (NPPs)

This element covers the following aspects (see Table 5):

- — Learning from operating experience;
- — Work control methods;
- — Error prevention;
- — Document control and configuration;
- — Corrective action programmes;
- — Benchmarking.

For background information, see Refs [10, 17].

TABLE 5. DOCUMENT MANAGEMENT (NPPs)

No.	Key words	Description of criteria
1	Incorporation of knowledge management methods	Are knowledge management methods incorporated into procedures and processes rather than being separate add-on tasks?
2	Learning from experience	Does the organization have a comprehensive methodology that addresses learning from experience?
3	Self-assessments	Are self-assessments regularly used to enhance organizational knowledge?
4	External benchmarking	Is external benchmarking regularly used to enhance organizational knowledge by adopting good industry practices?
5	Operational experience feedback	Is feedback from operational experience, internal and external, used by the organization for corrective action planning?
6	Work team composition	Is the composition of work teams (such as individual expertise/experience) considered in order to enhance knowledge transfer?
7	Work activity documentation	Are all work activities documented in such a way that knowledge can be effectively retrieved, shared and utilized?
8	Technical and organizational changes	Are procedures, drawings, lesson plans and related documentation updated promptly in a systematic way to address technical and organizational changes?
9	Design basis information	Does the organization maintain updated configuration information and design basis for NPP?

II.2.5. Technical IT solutions (NPPs)

This element covers the following aspects (see Table 6):

- — Knowledge databases;
- — Content and document management systems;
- — Search engines;
- — Portals and intranets;
- — Wikis and blogs;

— Skill and competency databases;
— Expert yellow pages;
— Enterprise resource planning;
— Other IT supporting systems.

For background information, see Refs [18–20].

TABLE 6. TECHNICAL IT SOLUTIONS (NPPs)

No.	Key words	Description of criteria
1	IT and knowledge management strategy	Are IT and knowledge management strategies aligned?
2	Information management	Is the organization utilizing an integrated approach to managing its information?
	Does the organization utilize appropriate IT support systems and tools such as:	
3	Content management	Content and document management
4	Concept mapping	Concept mapping
5	Knowledge management databases	Knowledge databases
6	Simulation tools	Simulation tools (e.g. simulators, computer based training and multimedia simulations)
7	Enterprise resource planning	Enterprise resource planning
8	Portals	Portals and intranets
9	Search engines	Knowledge search engines
10	Yellow pages	Expert yellow pages
11	Expert systems	Expert systems
12	Collaboration tools	Wikis and blogs

II.2.6. Tacit knowledge capture (NPPs)

This element covers the following aspects (see Table 7):

— Taxonomy development;
— Process for critical knowledge identification;
— Processes for knowledge elicitation/harvesting;
— Concept mapping;
— Communities of practice;
— Coaching and mentoring.

For background information, see Refs [1, 2, 18].

TABLE 7. TACIT KNOWLEDGE CAPTURE (NPPs)

No.	Key words	Description of criteria
1	Critical knowledge identification	Does the organization utilize methods to identify people who have critical knowledge?
	Does the organization adopt effective techniques to capture this knowledge, such as:	
2	Elicitation interviews	Elicitation interviews
3	Video capture	Video capture
4	On the job training	On the job training dialogue
5	Mentoring/coaching	Mentoring/coaching
6	Communities of practice	Communities of practice
7	Explicit capture	Explicit capture (narrative documentation)
8	Card sorting	Card sorting (manual concept map)
9	Concept mapping	Concept mapping
10	Process mapping	Process mapping
11	Storytelling	Storytelling
13	Knowledge search and retrieval	Is knowledge retained and presented in an effective way to facilitate search and retrieval?
14	Utilization of captured knowledge	Does the organization have processes for the effective utilization of captured knowledge?

II.2.7. Knowledge management culture (NPPs)

This element covers the following aspects (see Table 8):

- — No blame environment;
- — Knowledge sharing;
- — Leadership and commitment.

For background information, see Refs [20–23].

TABLE 8. KNOWLEDGE MANAGEMENT CULTURE (NPPs)

No.	Key words	Description of criteria
1	Promote transfer of knowledge	Does the culture of the organization promote the transfer of knowledge, particularly tacit knowledge, among personnel?
2	No blame culture	Does the organization have an open, no blame approach to reporting incidents, events and sharing of lessons learned?
3	Knowledge sharing rewards	Is sharing of knowledge in the organization recognized and rewarded?
4	Lead by example	Do managers lead by example by performing practical, visible leadership that supports the knowledge management strategy?
5	Individuals and teams	Do managers encourage trust, cooperation and collaboration between individuals and teams?

II.3. KNOWLEDGE MANAGEMENT ASSESSMENT CRITERIA FOR R&D ORGANIZATIONS

Criteria that are considered as key elements toward an effective approach to knowledge management have been identified. The criteria have been grouped into the following eight organizational or functional categories to facilitate the knowledge management maturity assessment:

(1) Policy or strategy for knowledge management;
(2) Human resource planning and processes;
(3) Competence development;
(4) Methods, procedures and documentation processes for improving knowledge management;
(5) Technical IT solutions;
(6) Approaches to capture and use tacit knowledge;
(7) Knowledge management culture or workforce culture that supports knowledge management;
(8) External collaboration.

II.3.1. Policy and strategy for knowledge management (R&D)

Table 9 presents knowledge management assessment criteria for the policy and strategy element for knowledge management. For background information, see Refs [7, 9, 10, 24].

TABLE 9. POLICY AND STRATEGY FOR KNOWLEDGE MANAGEMENT (R&D)

No.	Key words	Description of criteria
1	Knowledge management policy	Does the organization have a policy for implementing its knowledge management strategy?
2	Integration of a knowledge management policy	Is this knowledge management policy integrated into the management system?
3	Intellectual property policy	Does the organization have a written policy for implementing its knowledge management strategy?
4	Security of knowledge and information	Does the organization have a security policy for knowledge and information?

TABLE 9. POLICY AND STRATEGY FOR KNOWLEDGE MANAGEMENT (R&D) (cont.)

No.	Key words	Description of criteria
5	Security standards	If the organization has a security policy, is this based on industry best practices or national or international standards?
6	Communication of knowledge management policy	Is the knowledge management policy communicated to all staff in the organization?
7	Responsibilities for a knowledge management strategy	Is there a clear identification of those responsible for formulating and implementing the knowledge management strategy in the organization?
8	External technical service	Does the organization have policies or processes in place to ensure that adequate responsibility for knowledge preservation is taken when supplying or relying on external technical services?
9	Continual learning	Does the organizations' strategic focus support continual learning to improve individual and organizational performance?
10	Design rationale	Does the organization have processes in place to capture R&D decisions and design rationale?
11	Safety culture/knowledge management alignment	Is the organization's knowledge management policy aligned with continued emphasis on a strong safety culture?

II.3.2. Human resource planning and knowledge management processes (R&D)

Table 10 presents knowledge management assessment criteria for the human resource planning and knowledge management processes element. For background information, see Refs [7, 11, 12, 25].

TABLE 10. HUMAN RESOURCE PLANNING AND PROCESSES FOR KNOWLEDGE MANAGEMENT (R&D)

No.	Key words	Description of criteria
1	Workforce planning	Does the organization implement a comprehensive workforce planning methodology to ensure that human resource needs, both current and future, are met (workforce planning)?
2	Succession planning	Is there a succession planning programme in place?
3	Knowledge risk assessment	Are risk assessments carried out to identify potential loss of critical knowledge and skills?
4	Exit interviews	Are exit interviews carried out to capture critical knowledge and experience when people leave the organization?
5	Talent programme	Does a programme exist to develop new leadership or technical talent in a timely manner?
6	Competency assurance technicians	Does the organization utilize job profiles or the equivalent to assess and monitor its skills and competency needs of technicians?
7	Competency assurance scientists	Does the organization utilize job profiles or the equivalent to assess and monitor its skills and competency needs of scientists?

II.3.3. Training and human performance improvement (R&D)

Table 11 presents knowledge management assessment criteria for the training and human performance improvement element. For background information, see Refs [13–16, 26].

TABLE 11. TRAINING AND HUMAN PERFORMANCE IMPROVEMENT (R&D)

No.	Key words	Description of criteria
1	Performance appraisal	Does the organization conduct performance appraisals on a regular basis?
2	Competence development	Does the organization encourage participation and knowledge sharing at conferences, internal seminars and similar activities such as publications?
3	Metrics	Does the organization utilize metrics for the above (e.g. number of publications, impact factor for scientific journals, citations)?
4	Research reactor formal/systematic training	Does the organization have a formal or systematic training programme for nuclear facility operators?
5	Refresher trainings	Is regular refresher training carried out to maintain and enhance competence?
6	Human resource improvement programmes	Does the organization have a formal human performance improvement programme to maintain and enhance competence?
7	Coaching and mentoring	Are coaching and mentoring approaches used to support knowledge sharing?

II.3.4. Document management (R&D)

Table 12 presents knowledge management assessment criteria for the document management element. For background information, see Refs [10, 17, 27].

TABLE 12. DOCUMENT MANAGEMENT (R&D)

No.	Key words	Description of criteria
1	Knowledge management methods incorporation	Are knowledge management methods incorporated into procedures and processes rather than being separate add-on tasks?
2	Learning from experience	Does the organization have a comprehensive methodology that addresses learning from experience?
3	Self-assessments	Are self-assessments regularly used to enhance organizational knowledge?
4	External benchmarking	Is external benchmarking regularly used to enhance organizational knowledge by adopting good industry practices?
5	R&D experience feedback	Is the feedback (internal and external) from operational experience (lessons learned) used by the organization for corrective action planning to achieve improvements?

TABLE 12. DOCUMENT MANAGEMENT (R&D) (cont.)

No.	Key words	Description of criteria
6	Work team composition	Is the composition of work teams (such as individual expertise and experience) considered in order to enhance knowledge transfer?
7	Annual report	Does the organization publish or distribute a scientific annual report?
8	Work activity documentation	Are all work activities documented in such a way that knowledge can be effectively retrieved, shared and utilized?
9	Technical and organizational changes, lifecycle management	Are procedures, software, input data, codes, drawings, lesson plans and related documentation updated promptly and preserved in a systematic way to address technical and organizational changes?
10	Irradiation facilities	Does the organization maintain updated configuration information and design basis for nuclear irradiation facilities (beams and loops)?

II.3.5. Technical IT solutions (R&D)

Table 13 presents knowledge management assessment criteria for the technical IT solutions element. For background information, see Refs [18–20, 28, 29].

TABLE 13. TECHNICAL IT SOLUTIONS (R&D)

No.	Key words	Description of criteria
1	IT/knowledge management strategy	Are IT and knowledge management strategies aligned?
2	Information management	Is the organization utilizing an integrated approach in managing its information?
	Does the organization utilize the IT support systems and tools described in points 3–18:	
3	Scientific library	Scientific library
4	Scientific journals	Scientific journals (reachable on paper or via intranet/internet)
5	Citation index database	Citation index database
6	Nuclear event database	Nuclear event database
7	Research reactor event database	Research reactor event database
8	Simulators, computer based training, multimedia	Does the organization have a training programme that utilizes appropriate tools, such as simulators, computer based training, multimedia simulations, movies and photos to capture and transfer critical knowledge?
9	Concept mapping	Concept mapping
10	Knowledge bases	Knowledge bases
11	Simulation tools	Simulation tools
12	Enterprise resource planning	Enterprise resource planning

TABLE 13. TECHNICAL IT SOLUTIONS (R&D) (cont.)

No.	Key words	Description of criteria
13	Portals	Portals or intranets
14	Search engines	Knowledge search engines
15	Yellow pages	Expert yellow pages (including individual expert publications and competencies)
16	Expert systems	Expert systems
17	Wikis/blogs	Wikis/blogs
18	Others	Others? (please specify if any)

II.3.6. Tacit knowledge capture (R&D)

Table 14 presents knowledge management assessment criteria for the tacit knowledge capture element. For background information, see Refs [1, 2, 18].

TABLE 14. TACIT KNOWLEDGE CAPTURE (R&D)

No.	Key words	Description of criteria
1	Critical knowledge identification	Does the organization utilize formal methods to identify experts who have critical knowledge?
2	Techniques to capture knowledge and transfer knowledge	Does the organization adopt effective techniques to capture and transfer this knowledge, such as:
3	Elicitation interviews	Elicitation interviews
4	Video capture	Video capture
5	On the job training	On the job training dialogue
6	Mentoring or coaching	Mentoring or coaching
7	Communities of practice	Communities of practice
8	Explicit capture	Explicit capture (narrative documentation)
9	Card sorting	Card sorting (manual concept map)
10	Concept mapping	Concept mapping
11	Process mapping	Process mapping
12	Storytelling	Storytelling
13	Others	Others? (please specify if any)
14	Knowledge search and retrieval	Is knowledge retained and presented in an effective way to facilitate search and retrieval?
15	Utilization of captured knowledge	Does the organization have processes for the effective utilization of captured knowledge?

II.3.7. Knowledge management culture (R&D)

Table 15 presents knowledge management assessment criteria for the knowledge management culture element. For background information, see Refs [20–23].

TABLE 15. KNOWLEDGE MANAGEMENT CULTURE (R&D)

No.	Key words	Description of criteria
1	Promote transfer of knowledge	Does the culture of the organization promote the transfer of knowledge, particularly tacit knowledge, among personnel?
2	No blame culture	Does the organization have an open, no blame approach to reporting incidents or events and sharing of lessons learned?
3	Knowledge sharing rewards	Is sharing of knowledge in the organization recognized and rewarded?
4	Lead by example	Do managers lead by example by performing practical, visible leadership that supports the knowledge management strategy?
5	Individuals and teams	Do managers encourage trust, ethics, cooperation and collaboration between individuals and teams?

II.3.8. External collaboration (R&D)

Table 16 presents knowledge management assessment criteria for the external collaboration element. For background information, see Ref. [4].

TABLE 16. EXTERNAL COLLABORATION (R&D)

No.	Key words	Description of criteria
1	Higher education	Does your organization have regular collaboration with higher education institutions?
	Does this collaboration include points 2–8 below?	
2	Teaching in higher education	Do research staff teach at higher education institutes?
3	Teaching in R&D organization	Do higher education staff teach at the R&D organization (including supervision of PhD activities)?
4	Joint research projects	Is there participation in joint research projects?
5	Communities of practice	Is there participation in communities of practice?
6	Joint seminars	Is there participation in joint seminars?
7	Other R&D institutions	Does the organization have regular collaboration with other national R&D institutions?
8	Other R&D institutions	Does the organization have regular collaboration with foreign R&D institutions?

II.4. KNOWLEDGE MANAGEMENT ASSESSMENT CRITERIA FOR EDUCATIONAL INSTITUTIONS

To compare and assess nuclear engineering courses delivered at any educational institution in any country, it is important to establish a consistent set of criteria. These can then be used for any visit by experts or IAEA personnel and will provide the structure for KMAVs. Eight specific assessment and benchmarking criteria have been identified an include:

- Policy, strategy, vision and mission of the educational institution;
- Capacity to deliver nuclear engineering programmes, with particular reference to the staff and facilities;
- Educational curricula;
- Outcomes of the programme, including graduate employment, further education, etc.;
- Professional accreditation;
- Human resource policy;
- National and international dimensions;
- Collaboration with industry.

An assessment of the standard of the educational institution in each of these criteria (see Table 17) will enable suitable benchmarking to be undertaken, not only with other organizations, but also over time with historical data. For background information, see Ref. [5].

II.4.1. Policy, strategy, vision and mission (educational institutions)

Table 17 presents knowledge management assessment criteria.

TABLE 17. POLICY, STRATEGY, VISION AND MISSION (EDUCATIONAL INSTITUTION)

No.	Key words	Description of criteria
1	Organizational policy vs national policy	The educational institution and the nuclear engineering department's policy, strategy, vision and mission are aligned with the national policy.
2	Importance of nuclear education	The provision of nuclear education is important to the overall organization.
3	Programme level	What is the degree level of the nuclear engineering programme, for example undergraduate, postgraduate or PhD? (4 = the complete programme covering all degree levels, 3 = postgraduate and PhD levels, 2 = postgraduate level, 1 = undergraduates only).
4	Time horizon	The short, medium and long term strategies of the organization and department are fully developed.
5	Collaboration with industry	There is full collaboration with industry, and contributions to the delivery of the programme are fully exploited.
6	International dimensions	There are international dimensions of the organization, department and programme.
7	Student selection criteria	There is a strategy for enrolling students and adequate criteria for student selection.
8	Attracting high calibre students	There is a successful strategy for attracting high quality students.
9	Alumni communication	There is a strategy in place to track and maintain interaction with alumni.

TABLE 17. POLICY, STRATEGY, VISION AND MISSION (EDUCATIONAL INSTITUTION) (cont.)

No.	Key words	Description of criteria
10	Allocation of responsibilities	Responsibilities are clearly and reasonably split between the organization, department and staff.
11	Communication policy	There is a communication policy in place and the key stakeholders (internal and external) receive the communication.
12	Knowledge management policy	There is a knowledge management policy that is fully implemented.

II.4.2. Capacity to deliver nuclear engineering programmes (educational institutions)

Table 18 presents knowledge management assessment criteria for the capacity to deliver nuclear engineering programmes element.

TABLE 18. CAPACITY TO DELIVER NUCLEAR ENGINEERING PROGRAMMES (EDUCATIONAL INSTITUTIONS)

No.	Key words	Description of criteria
1	Staff qualification and quantity	Qualifications and quantity of staff correspond to the needs of the nuclear engineering programmes
2	Experimental facilities	The experimental facilities at the university, or access arrangements to experimental facilities in other organizations, are fully utilized.
3	Simulators	The use of simulators is fully integrated into the educational programme.
4	Libraries	Sufficient top quality library facilities exist and are easy to access.
5	Computer facilities	Sufficient top quality computer facilities exist and are easy to access.
6	Peer reviewed publications	Peer reviewed educational materials and publications authored by the department sufficiently support the efficient implementation of the nuclear engineering programme.
7	Knowledge sharing	The conference/workshop/seminar attendance policy (including internal) enables knowledge sharing.
8	Scholarship availability	Scholarships for students who meet selection criteria are available.
9	Part time work	The programme is flexible enough to allow students time to supplement their income through paid work if needed.
10	Advanced tools	Distance learning and e-learning tools are used, and are implemented.
11	Programme ranking	The programme is highly ranked nationally and internationally.
12	Student–teacher ratio	The student–teacher ratio for lectures, tutorials and practical coursework is adequate for programme implementation.
13	Courses in a foreign language	The programme offers courses in at least one foreign language.
14	Participation in R&D activities	Participation of students in R&D activities is an effective part of the education programme.

II.4.3. Educational curricula (educational institutions)

Table 19 presents knowledge management assessment criteria for the educational curricula element.

TABLE 19. EDUCATIONAL CURRICULA (EDUCATIONAL INSTITUTIONS)

No.	Key words	Description of criteria
1	Course prerequisites (1)	The core courses are supported by general courses of mathematics, general physics, chemistry, engineering, computational and foreign language courses.
2	Course prerequisites (2)	Nuclear engineering students achieve the required level of competency in the general courses before taking the core courses.
3	General and specific competencies	The general and specific competencies students must have are defined for the programme.
4	Core courses	The core courses are mandatory.
5	Elective courses	The elective courses support the general and specific competencies defined for the programme.
6	Soft competencies	Soft competences, such as communication, team work, basic business/finance, project management and knowledge management, are incorporated into the overall programme.
7	Nuclear industry needs	The nuclear industry requirements for both power and non-power applications are fully reflected in the curricula.
8	Student feedback	Student feedback is gathered, reported and contributes to the development of the programme.
9	Programme evaluation	The overall programme contributes to continual improvement.

II.4.4. Outcomes of the programme (educational institutions)

Table 20 presents knowledge management assessment criteria for the outcomes of the programme element.

TABLE 20. OUTCOMES OF THE NUCLEAR ENGINEERING PROGRAMME (EDUCATIONAL INSTITUTIONS)

No.	Key words	Description of criteria
1	Graduation rate	What is the graduation rate for the courses? (4 = high, 0 = low).
2	Relationship with alumni	Relationships with alumni are maintained? (4 = well established process, 0 = not at all).
3	Graduates in nuclear profession follow-up	Connection is maintained throughout the career of the graduates who remain in the nuclear profession.
4	Graduates’ career follow-up	Connection is maintained throughout the career of the graduates who remain in the nuclear profession.

TABLE 20. OUTCOMES OF THE NUCLEAR ENGINEERING PROGRAMME (EDUCATIONAL INSTITUTIONS) (cont.)

No.	Key words	Description of criteria
5	Industry demand	What is the industry demand for the graduates? (4 = high, 0 = low).
6	Link with employing organizations	Feedback and evaluations from the employing organizations provide input to continually improve the programme.
7	Evaluation by graduates	Feedback and evaluations from graduates provide input to continually improve the programme.

II.4.5. QUALITY AND ACCREDITATION (EDUCATIONAL INSTITUTIONS)

Table 21 presents knowledge management assessment criteria for the quality and accreditation element.

TABLE 21. QUALITY AND ACCREDITATION (EDUCATIONAL INSTITUTIONS)

No.	Key words	Description of criteria
1	Policy for education quality	The educational institution pursues policies in order to provide quality education.
2	Improvement of education quality	The educational institution is able to demonstrate that it systematically improves the quality of its programmes.
3	Quality programme	The educational institution has an effective system and decision making structure with regard to the quality of its programmes, which clearly defines tasks, authorities and responsibilities.
4	Accreditation process	The accreditation process to ensure quality in nuclear engineering academic programmes is established and well defined.
5	Impact of accreditation	The guidance offered by the accrediting organization are mandatory for the educational institution.
6	Accreditation follow-up	The educational institution fully addresses any identified shortcomings in an effort to regain accreditation as soon as possible.

II.4.6. HUMAN RESOURCE POLICY (EDUCATIONAL INSTITUTIONS)

Table 22 presents knowledge management assessment criteria for the human resource policy element.

TABLE 22. HUMAN RESOURCE POLICY (EDUCATIONAL INSTITUTIONS)

No.	Key words	Description of criteria
1	Attracting quality people	Policies are established to attract quality people to the programme and to retain them.
2	Performance review system	There is a performance review system and it is implemented. The educational institution utilizes metrics for it.

TABLE 22. HUMAN RESOURCE POLICY (EDUCATIONAL INSTITUTIONS) (cont.)

No.	Key words	Description of criteria
3	Visiting staff and sabbaticals	There is a comprehensive policy on visiting staff, and sabbaticals for existing staff, that supports the overall human resource policy of the educational institution.
4	Succession planning	There is a constantly evolving succession plan.
5	Competence development	There is a special development programme for less experienced staff (e.g. young teachers) that is fully implemented.
6	Senior/retired staff experience	Experience of nuclear experts close to retirement, or who have retired, is captured and fully utilized.
7	Knowledge loss risk assessment	Periodic risk assessments for the loss of experienced teaching staff have been undertaken.
8	Academic staff development	There is a recruitment, retention and career development policy for academic staff that is fully utilized.
9	Support staff development	There is a recruitment, retention and career development policy to support staff that is fully utilized.
10	Coaching and mentoring	Coaching and mentoring approaches are used to support knowledge sharing.

II.4.7. NATIONAL AND INTERNATIONAL DIMENSIONS (EDUCATIONAL INSTITUTIONS)

Table 23 presents knowledge management assessment criteria for the national and international dimensions element.

TABLE 23. NATIONAL AND INTERNATIONAL DIMENSIONS (EDUCATIONAL INSTITUTIONS)

No.	Key words	Description of criteria
1	Networks and forums	Participation in educational and professional networks and forums is fully encouraged.
2	Link with professional societies	Links with professional (learned) associations and societies are fully supported.
3	Interaction with national and international agencies	Full interaction exists with national and international agencies.
4	Studies at other educational institutions	Students are encouraged to undertake part of their studies at other national or international educational institutions.
5	External teaching	Teaching staff teach at other national or international educational institutions.
6	Agreements with educational institutions	There are memorandums of understanding or agreements with other national or international educational institutions.
7	Visiting teaching staff	Part of the nuclear engineering programme is taught by visiting staff from other national or international educational institutions.

II.4.8. Collaboration with industry (educational institutions)

Table 24 presents knowledge management assessment criteria for the collaboration with industry element.

TABLE 24. COLLABORATION WITH INDUSTRY (EDUCATIONAL INSTITUTIONS)

No.	Key words	Description of criteria
1	External advisory board	There is an external advisory board and its input is fully utilized by the organization.
2	Internship/industry	Industry provides internships for students.
3	Student support	Industry supports students through prizes, awards and scholarships.
4	Support for diploma	Industry offers support for theses (diploma) work by providing project placements and financial support for students to cover any associated costs.
5	Support for infrastructure development	Industry offers support for theses (diploma) work by providing project placements and financial support for students to cover any associated costs.
6	Joint research projects	There are joint research projects between academia and industry.
7	Professional development of personnel	Staff members attend courses within industrial facilities for continual upgrading and professional development of personnel.
8	Development of industry personnel	The educational institution offers courses for professional development of industry personnel.
9	Industry specialists involved in educational process	Industry specialists are involved in the educational process.
10	Membership in industry forums, on the boards of regulatory bodies or in industry networks	Staff members are involved in industry forums, serve on the boards of regulatory bodies or are members of industry networks.

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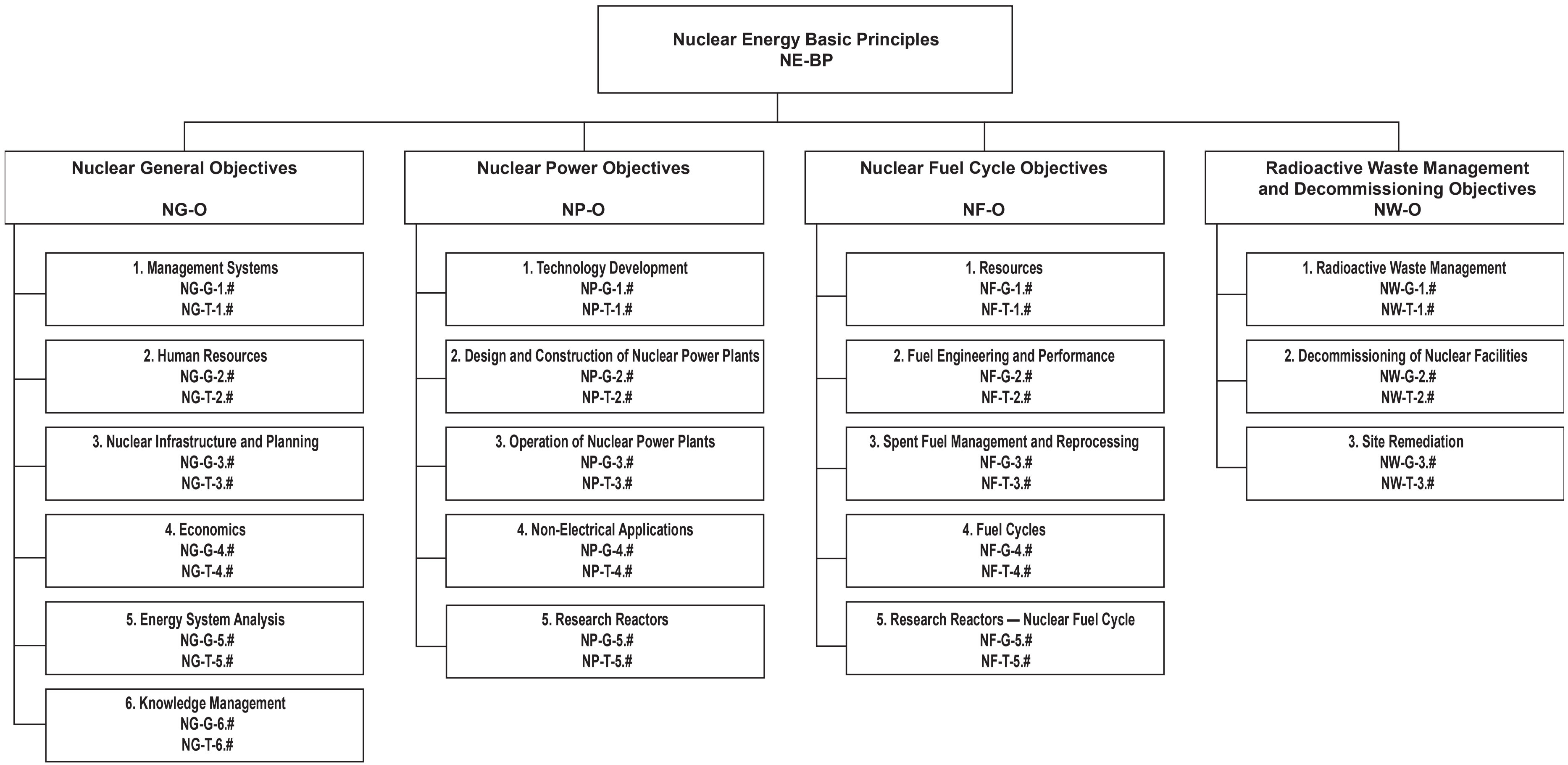

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