IAEA Nuclear Energy Series

No. NG-G-6.1

Guide to Knowledge Management Strategies and Approaches in Nuclear Energy Organizations and Facilities

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GUIDE TO KNOWLEDGE MANAGEMENT STRATEGIES AND APPROACHES IN NUCLEAR ENERGY ORGANIZATIONS AND FACILITIES

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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''.

IAEA NUCLEAR ENERGY SERIES No. NG-G-6.1

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INTERNATIONAL ATOMIC ENERGY AGENCY
VIENNA, 2022

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email: sales.publications@iaea.org
www.iaea.org/publications

Printed by the IAEA in Austria
October 2022
STI/PUB/1957

IAEA Library Cataloguing in Publication Data

Names: International Atomic Energy Agency.
Title: Guide to knowledge management strategies and approaches in nuclear energy organizations and facilities / International Atomic Energy Agency.
Description: Vienna : International Atomic Energy Agency, 2022. | Series: IAEA nuclear energy series, ISSN 1995–7807 ; no. NG-G-6.1 | Includes bibliographical references.
Identifiers: IAEAL 22-01499 | ISBN 978–92–0–125721–5 (paperback : alk. paper) | ISBN 978–92–0–125821–2 (pdf) | ISBN 978–92–0–125921–9 (epub)
Subjects: LCSH: Knowledge management. | Nuclear industry — Management. | Nuclear facilities — Management.
Classification: UDC 621.039:005.94 | STI/PUB/1957

FOREWORD

The IAEA's statutory role is to "seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world". Among other functions, the IAEA is authorized to "foster the exchange of scientific and technical information on peaceful uses of atomic energy". One way this is achieved is through a range of technical publications including the IAEA Nuclear Energy Series.

The IAEA Nuclear Energy Series comprises publications designed to further the use of nuclear technologies in support of sustainable development, to advance nuclear science and technology, catalyse innovation and build capacity to support the existing and expanded use of nuclear power and nuclear science applications. The publications include information covering all policy, technological and management aspects of the definition and implementation of activities involving the peaceful use of nuclear technology.

The IAEA safety standards establish fundamental principles, requirements and recommendations to ensure nuclear safety and serve as a global reference for protecting people and the environment from harmful effects of ionizing radiation.

When IAEA Nuclear Energy Series publications address safety, it is ensured that the IAEA safety standards are referred to as the current boundary conditions for the application of nuclear technology.

Knowledge is central to the success of any high technology industry, including the nuclear industry. The risk of losing critical knowledge or failing to effectively use the lessons learned can be challenging for the safe, reliable and economical use of nuclear energy. The industry realized the impact of losing critical knowledge two decades ago and initiated focused knowledge management initiatives.

Since 2004, the IAEA has been supporting its Member States in this area by providing new guidance and carrying out knowledge management assist visits to address critical knowledge loss and to introduce beneficial knowledge management initiatives.

This publication provides guidance on knowledge management based on successful practices and approaches observed during IAEA missions and activities and on the knowledge and experience of the knowledge management experts.

This publication provides a structured approach to developing a strategic knowledge management programme that is aligned with the business objectives of the organization and that delivers both safety and economic benefits. It provides guidance on integrating knowledge management activities into an organization's business processes.

Although this publication's primary aim is to provide guidance to organizations and facilities in the field of nuclear energy, the concepts and

approaches will be useful for other nuclear organizations and facilities as well. The publication is applicable to the entire life cycle of nuclear facilities and activities, from siting to design, licensing, construction, commissioning, operation, modernization and decommissioning.

The IAEA wishes to acknowledge the assistance of those who contributed to the production of this publication. The IAEA officers responsible for this publication were A. Ganesan and D. Drury of the Division of Planning, Information, and Knowledge Management.

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

The impact of losing critical knowledge was recognized by many nuclear energy organizations in the late 1990s and early 2000s when a significant number of first generation nuclear professionals left the industry or retired, and consequently the industry lost significant years of knowledge and experience [1]. This issue became more significant as there was stagnation in the growth of the nuclear energy industry coupled with declining interest in pursuing nuclear education. This prompted some of the nuclear energy organizations to start focusing on people-centric knowledge management programmes with activities aimed at mitigating the risk of critical knowledge loss.

On the basis of the IAEA General Conference resolution GC(62)/RES/9, this publication provides guidance and methodologies for planning, designing, implementing and evaluating nuclear knowledge management programmes and practices.

When starting to develop knowledge management programmes, organizations were often confronted with following questions related to knowledge management.

(a) What benefits can an organization expect from knowledge management (i.e. why should an organization be interested in knowledge management)?
(b) How can an organization achieve these benefits in the most cost effective way (i.e. avoiding adding people or complexity to the organization)?
(c) Can knowledge management be integrated with the organization's existing management systems/business processes (i.e. is it possible to incorporate knowledge management programmes by improving the existing business processes)?
(d) How much time and effort will be needed?

This publication provides useful insights into these issues as well as guidance for the introduction of a strategic knowledge management programme that can provide both safety and financial benefits, in addition to reducing the risk of knowledge loss.

The guidance and recommendations provided in this publication are based on the experiences gained by the IAEA and the good practices and approaches it has learned through conferences, technical meetings, workshops and knowledge

management assist visits to nuclear organizations in the area of knowledge management over a period of more than 15 years.

1.2. OBJECTIVE

The objective of this publication is to provide guidance for developing a strategic knowledge management programme for organizations in the field of nuclear energy; first and foremost for those organizations that operate nuclear facilities. It is also relevant for those government and industry organizations that design, construct, license, regulate, decommission, provide technical support for and educate and train specialists for nuclear facilities. Guidance provided here, describing good practices, represents expert opinion but does not constitute recommendations made on the basis of a consensus of Member States.

1.3. SCOPE

This publication is intended for those organizations that either directly or indirectly support the use of nuclear energy, including:

(a) All facilities involved in the nuclear fuel cycle for a nuclear power programme, including both the front end (e.g. mining, extraction, enrichment and fuel fabrication, nuclear power plants (NPPs)) and the back end (e.g. waste management, storage and disposal facilities);
(b) Organizations transporting radioactive material;
(c) Organizations involved in radiation protection activities;
(d) Organizations concerned with the regulation of such facilities and activities;
(e) Research and development organizations;
(f) Suppliers or contractors for nuclear facilities;
(g) Technical support organizations;
(h) Government ministries;
(i) Education and training organizations;
(j) Governments and organizations considering the introduction of nuclear programmes.

This publication applies to the entire life cycle of nuclear facilities and activities, including their siting, design, licensing, construction, commissioning, operation, modernization and decommissioning.

For the purpose of this publication, the term ‘nuclear facilities’ includes facilities concerned with the front end of the nuclear fuel cycle, such as those

involved in mining, extraction, enrichment and fabrication of fuel, as well as NPPs, and those concerned with the back end, including waste management, storage and disposal. The term 'nuclear organization' includes NPPs, research and development organizations, educational institutions, regulatory authorities, design and technical support organizations, waste processing and disposal organizations and decommissioning services organizations.

This publication is a guidance level document (level 3) in the IAEA Nuclear Energy Series and provides high level guidance or describes methods for the implementation of a strategic knowledge management programme in nuclear organizations. This publication specifically provides the following information:

(a) Why a knowledge management programme is beneficial, through the introduction of concepts and principles that highlight its importance;
(b) What actions are needed to introduce a strategic knowledge management programme that is aligned with organizational business objectives;
(c) How to implement a knowledge management programme and monitor its effectiveness.

This publication connects the reader with other relevant IAEA publications to obtain specific guidance on related topics.

Leaders and decision makers in industry, academia and government, senior and middle level managers and knowledge management specialists in nuclear organizations, are the potential target audience for this publication.

1.4. STRUCTURE

This publication is structured to first explore why there is a need for strategic knowledge management programmes in nuclear organizations and then provides guidance for implementation.

Section 2 provides guiding principles and their attributes for a successful knowledge management programme with the objective of creating a better understanding of knowledge management issues in nuclear organizations. It provides information about the importance of integrating knowledge management programmes with business processes or management systems. It also provides a brief introduction to basic concepts and terms related to knowledge management for the benefit of readers who are new to the knowledge management world.

Section 3 introduces commonly followed organizational practices that promote knowledge management and specific knowledge management projects to achieve specific objectives.

Section 4 provides guidance for developing a knowledge management strategy and describes its important attributes.

Section 5 provides step by step guidance for implementing knowledge management programmes using a roadmap approach.

Section 6 describes some of the challenges for the implementation of knowledge management programmes.

Section 7 summarizes the important areas of this publication.

2. DEFINING KNOWLEDGE MANAGEMENT IN THE NUCLEAR FIELD

As is the case with many management terms, a variety of definitions are provided in the literature for knowledge management. The definition that the IAEA has adopted is:

> "An integrated, systematic approach to identifying, managing and sharing an organization's knowledge and enabling groups of people to create new knowledge collectively to help in achieving the organization's objectives" [2].

This definition from the IAEA is focused on the organizational level to support the active and ongoing human resource development programmes in place for nuclear facilities and organizations.

However, the IAEA's experience is that in many Member States there are also national level needs related to education, training, human resource development (HRD) and technology, among other factors, to enable nuclear organizations to effectively implement knowledge management strategies and methods.

Section 2.1 provides some guiding principles related to knowledge management in nuclear organizations. These principles provide insights into why knowledge management is important for an organization and how it is linked to organizational activities and business processes.

2.1. PRINCIPLES OF KNOWLEDGE MANAGEMENT IN THE NUCLEAR FIELD

In this section, some principles of knowledge management are provided with explanations and examples to help the reader understand the impact of knowledge management activities on the business objectives of a nuclear organization. The aim is to give readers a comprehensive understanding of the issues connected with knowledge management in the nuclear field before they begin developing a knowledge management programme.

2.1.1. Principle 1

Organizational knowledge resides in its employees, its business processes and in science and technology deployed by the organization.

The knowledge required for successful conduct of business by an organization will reside in one of the following three domains, as depicted in Fig. 1.

(a) The knowledge possessed by individuals and teams of an organization. Organizations use training and qualification programmes to impart relevant knowledge, skills and attitudes to personnel to enable them to perform select functions and activities. For example, control room operators at NPPs are trained and qualified to ensure that they possess suitable competencies to operate the plant under all anticipated conditions. In addition, personnel gain significant knowledge and experience as they work through an organization.

(b) The knowledge embedded in an organization's business processes. In order to execute business activities efficiently and effectively, organizations introduce standard business processes. For example, NPPs have work management processes to control and execute large numbers of maintenance and testing activities with due consideration of both plant safety and optimization of outage time. Similarly, NPPs have configuration control processes to ensure that the plant system's configuration is maintained within the design envelope under all operating and shutdown conditions. Knowledge of the business processes is essential to use them effectively.

(c) The knowledge associated with the science and technology used by the organization. Usually this type of knowledge is available in the form of technical documents such as design documents, plant operating procedures, equipment specifications and drawings, and in the minds of the employees. Access to technical knowledge is essential for safe and efficient operation. Technical knowledge may be related to scientific, engineering, legal, environmental and other business requirements.

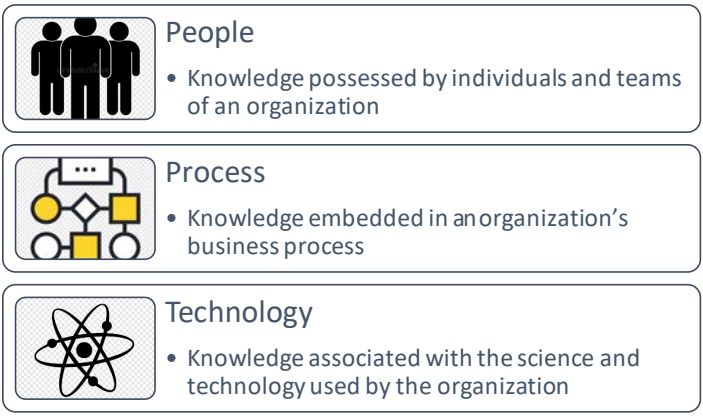

FIG. 1. Knowledge assets of an organization.

2.1.2. Principle 2

Knowledge required for safe and reliable operation of a nuclear facility may be available from an external organization.

Nuclear facilities use complex technologies and expertise from different engineering and science disciplines. Often, several organizations are involved in the design, construction and operation of a nuclear facility like an NPP. Organizations typically possess specialized knowledge in one or more core functions, such as design and engineering, construction, operation and maintenance, regulation and legal matters, and nuclear equipment manufacturing. As the facility enters the operational phase, it may need expertise and knowledge from design, engineering, construction or nuclear equipment manufacturing organizations in order to operate and maintain the facility safely and reliably.

A nuclear organization may wish to focus its efforts on certain core functional areas and outsource the remaining core and supporting functions from external organizations to reduce operational costs and associated human resource costs. Knowledge management initiatives, therefore, need to focus on creating an in-house knowledge base for the successful and efficient conduct of those identified functions that are managed within the organization. Further, the organization's knowledge management programme needs to have mechanisms to ensure that there are suitably qualified and experienced contractors or support organizations available for sustainable implementation of the remaining core and support functions.

The knowledge management issues associated with outsourcing and methodologies to assess the risk of knowledge loss in outsourced activities is

explained in IAEA-TECDOC-1884, Knowledge Management Perspectives on Outsourcing in Operating Nuclear Power Plants [3].

2.1.3. Principle 3

Recognize that industry operating experience, innovation and obsolescence may call for continuous improvements to a facility's structures, systems and components, regulations and business processes. This calls for new/updated knowledge to operate and manage the facility.

Typically, the original design life of an NPP is 30–60 years. However, based on detailed analysis and review, many NPPs are planning to extend this lifetime, for example up to 80 years, because extending the lifetimes of NPPs offers significant economic benefits. As the facility moves through its long operational life, improved technologies, regulations and practices may be introduced based on operating experience, industry innovations and requirements imposed by obsolescence. Therefore, over the operational life of a nuclear facility, it will be necessary to make several engineering and design changes to the facility's structures, systems and components, and these changes may strongly influence the knowledge needed for sustainable operation of the facility. The introduction of changes will require not only an understanding of, and education in, new technology, but also competencies that can integrate new technology into an existing facility that may be well into its operational life. A key example of such a technology and its effect on knowledge processes in the nuclear industry is the introduction of digital instrumentation and control devices and systems. Such control systems represent a fundamental challenge for new and legacy facilities alike in terms of technological knowledge. This may have a significant impact on existing techniques and requirements for the control of processes in nuclear facilities. Understanding the existing design basis, plant design and requirements is essential for an organization's ability to absorb core technologies as they evolve and change. Well planned and implemented configuration management control processes, along with well designed knowledge management programmes, will help in preserving and transferring critical knowledge to support this life extension programme.

2.1.4. Principle 4

It is useful and necessary to recognize the importance of knowledge management in nuclear industry early in the life cycle of a project.

Nuclear facility life cycles, starting from design through construction, commissioning and operation and up to decommissioning, may extend over 100 years. Several national and international organizations will participate in all or part of this journey. A nuclear organization gains a wealth of knowledge as it moves through the life cycle phases. The knowledge generated in one phase is beneficial in another phase. Many organizations recognize the importance of previous life cycle experience late in the operational phase. A good example of this is the use of experience and knowledge gained during facility commissioning and testing in the operational phase. During commissioning, system and component performance are extensively tested and validated. This experience and knowledge is valuable in addressing many technical challenges encountered during the operational phase. Figure 2 shows the typical organizations involved and their time of involvement in this journey. It is important to recognize the key knowledge stakeholders early in the life cycle and ensure that the critical knowledge created, including tacit knowledge, in each of the life cycle phases is captured and transferred so that it is useful in the subsequent phases.

Learning from lessons early in the life cycle and introducing a system to capture knowledge and experience as the facility moves through the life cycle phases is beneficial for nuclear organizations.

2.1.5. Principle 5

Knowledge management initiatives should be aligned with an organization's business objectives.

Introducing knowledge management initiatives involves considerable time and resources for an organization. However the benefits derived from such initiatives are often realized very late. For example, receiving the benefits of organization wide mentoring programmes that transfer vital knowledge from more experienced personnel to those less experienced takes considerable time. In order to understand the contribution of knowledge management initiatives, it is important to clearly identify the objectives of the programme and its link to the overall business objectives and, in particular, to the safety and business objectives. Performance indicators to monitor and evaluate the effectiveness of knowledge management programmes are essential to substantiate achievements and can be used to amend a programmatic activity to suit the requirements of the business.

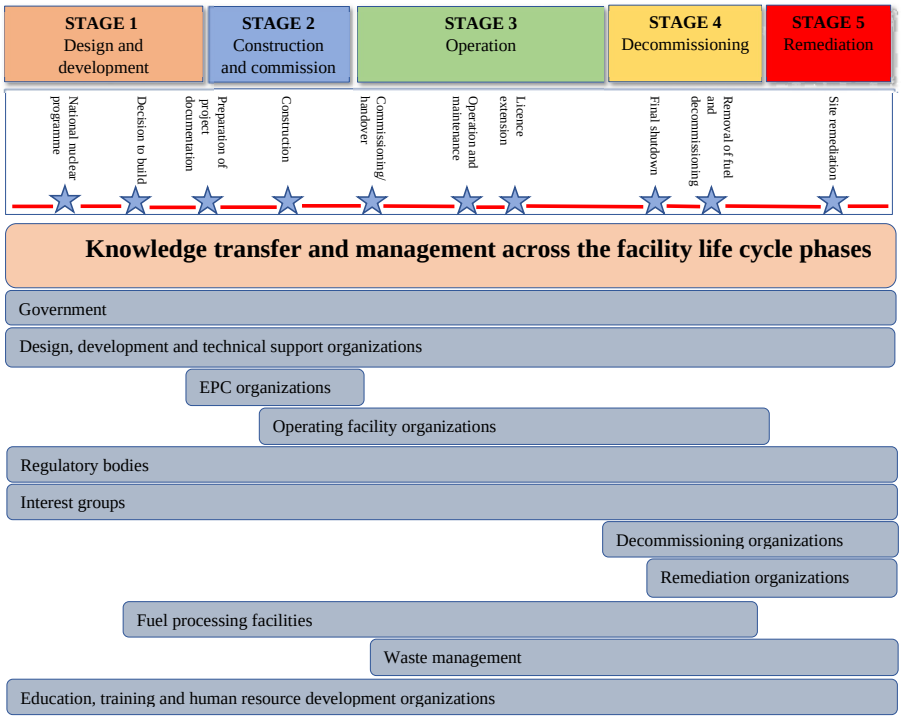

FIG. 2. Involvement of different organizations during the life cycle phases of a nuclear power programme.

2.1.6. Principle 6

Knowledge management initiatives or projects should be integrated with organizational business processes and management systems.

Knowledge management ought not to be viewed as an approach that duplicates existing business or management processes. Rather, knowledge management is an integrated, systematic approach to help make an organization's business or management processes more effective at capturing and transferring knowledge that it needs to make its current processes work better and to better prepare for future needs and challenges.

Many knowledge management initiatives follow the change management process and to achieve this it is often most expedient to embed the change into the 'business as usual' activities of the organization. The integration of knowledge management initiatives and actions into the processes and procedures of functional and operational activities ensures that they are perceived as 'what

we do' rather than as an optional add-on or overhead for standard activities. This approach has the advantage of passing the 'ownership' of the knowledge, and the responsibility for managing that knowledge, to the most appropriate agent.

2.1.7. Principle 7

An open knowledge sharing culture and ownership by personnel at all levels are keys to success .

Successful knowledge transfer initiatives in an organization require an open knowledge sharing culture. Organizations may invest significant resources and develop knowledge management initiatives and make them an integral part of the organization processes, but reap very few benefits, if they are not owned and implemented by personnel at all levels of the organization. For example, some nuclear organizations have created user friendly portals to facilitate sharing of operating experience information, but they have not always been effective in getting personnel to report the near misses and low level events or getting personnel to refer to this database to enable organizational learning from past experiences. Extra efforts are needed to improve the reporting and learning culture and to create awareness about the benefits associated with such knowledge management initiatives.

Organizations deploy different methods to promote a knowledge sharing culture, including reward and recognition schemes. Different approaches and strategies are required to achieve success as national cultures and environments significantly influence the approaches taken.

Leadership and individuals in the organization, through all levels of the management and leadership chain, need to foster a strong knowledge sharing culture.

2.1.8. Principle 8

Information technology enabled tools and applications play a vital role in supporting knowledge management.

Nuclear organizations use large amounts of documented information and structured processes to perform their activities, such as operation, maintenance, engineering changes and procurement. Information technology applications facilitate efficient storage, easy retrieval and effective control of modification of documented information.

Organizations around the world, including nuclear ones, use tailored information technology applications to conduct their business functions more

efficiently. The rapid advances in information technology over the past 30 years are providing new opportunities for the management of documented information and knowledge in nuclear organizations. Intelligent knowledge organization systems that use semantic tools, taxonomies and ontologies with capabilities to obtain information using keywords from large volume data sources in different formats are playing key roles in managing big data resources. These advancements are very useful for managing explicit knowledge.

2.2. KNOWLEDGE, INFORMATION AND DATA

In this section, the fundamental concepts and relationships of data, information and knowledge are briefly explained. Figure 3 explains the connection between data, information and knowledge. Organizations use and generate large volumes of data as they move through their life cycles. The data, when viewed independently, may not reveal any meaning. On the other hand, when they are structured or organized, they reveal useful information and have added significance. When data/information are analysed/interpreted by experienced personnel, they often yield useful knowledge that adds value to the business.

As an organization moves through time, it gains new knowledge through experience. It makes efforts to document such knowledge or transfer it to other employees in order to ensure the sustainability of organizational knowledge. In many cases, it is not only captured in documents, but also in organizational routines, practices and norms.

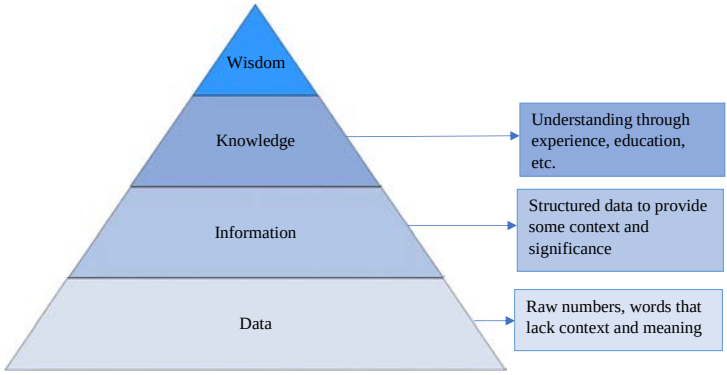

FIG. 3. Data, information and knowledge.

2.3. DIFFERENT TYPES OF KNOWLEDGE

A good understanding of different types of knowledge and the ability to distinguish between them is important for people dealing with knowledge management programmes.

The IAEA publications associated with nuclear knowledge management typically refer to two knowledge categories, explicit knowledge and tacit knowledge. The former refers to forms of knowledge that are relatively easy to acquire and are often found in documents. This explicit knowledge is also referred to as codifiable knowledge as this form of knowledge can be documented. Tacit knowledge refers to those forms of knowledge that are difficult to reveal and hence difficult to document. The experience gained by individuals is in some situations stored in the memory as framed experiences and it helps the individual to provide an expert insight/contextual information for evaluating problems or identifying solutions to complicated issues by exercising higher cognitive skills. It is sometimes termed intuition. This tacit knowledge is also referred to as non-codifiable knowledge or personal/experience based knowledge.

IAEA-TECDOC-1510, Knowledge Management for Nuclear Industry Operating Organizations [4], explains these two types of knowledge (see Fig. 4), and it also refers to a third type of knowledge called implicit knowledge, which resides between explicit and tacit knowledge.

2.3.1. Explicit knowledge

This type of knowledge is formalized and codified and is made available in a form that is easy to understand. Knowledge available in the form of guidance documents, procedures, policies, data stored in paper or computer formats, equipment drawings and specifications are some examples of explicit knowledge.

2.3.2. Tacit knowledge

Tacit knowledge resides in the minds of human beings and is difficult to define. It includes cultural beliefs, values, attitudes and mental models. Some of the skills, capabilities and expertise possessed by personnel come under this category.

As employees pass through the journey of working with an organization for several years, they gain experience and develop mastery of skills in certain activities. These skills and knowledge are not always straightforward to transfer to another employee or simple to capture accurately through documents or other forms. It may take several years for a new employee to acquire them by working closely with the possessor of the knowledge and skills. It is difficult to transfer

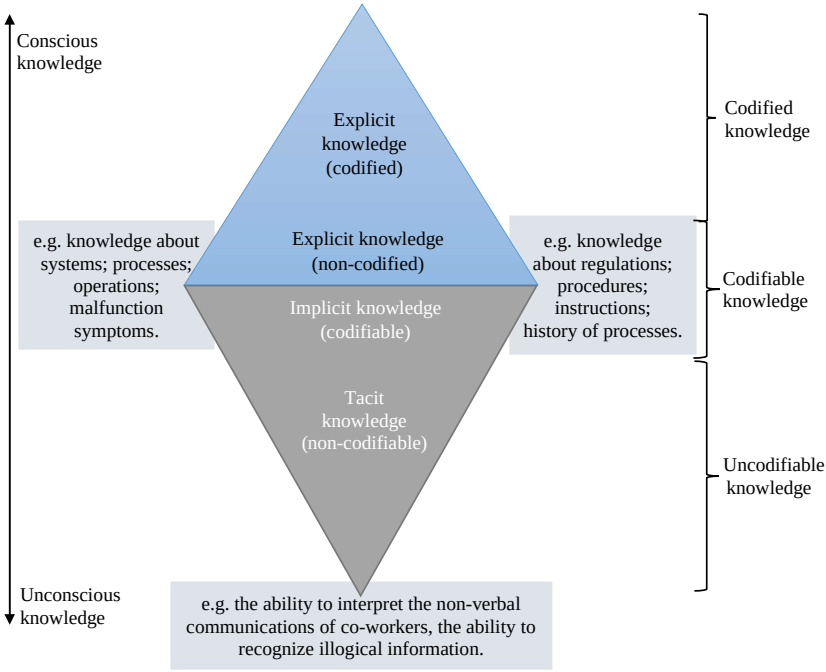

FIG. 4. Explicit, implicit and tacit knowledge [4].

tacit knowledge because it depends on the context of the job or activity and is deeply rooted in action, commitment and involvement.

Knowledge possessed by experienced designers and engineering solution providers is the most difficult tacit knowledge resource to acquire. Construction of large nuclear facilities involves specially acquired skills, knowledge and expertise related to civil and mechanical engineering. Some Member States/organizations once possessed state of the art skills to undertake large nuclear facility construction projects. As they have not had the opportunity to construct new facilities, many specialized skills to support construction have been lost over time. Consequently, it is difficult and often time consuming and expensive to re-establish the skills and knowledge required for new construction projects.

2.4. THE RELATIONSHIP BETWEEN INFORMATION MANAGEMENT AND KNOWLEDGE MANAGEMENT

Data and information are important foundations to build up knowledge. Therefore, effective and efficient data and information management is

important for successful knowledge management programmes. With advances in information technology, nuclear industry organizations now use information technology tools to a varied degree to exploit the benefits of organizing data and information for supporting efficient knowledge management solutions. The use of semantic technologies in organizing information and data is taking information management to the next domain. Intelligent search capabilities help users to obtain information efficiently from large sources of interconnected information and aid in implementing knowledge management solutions.

New methods of learning using modern information and communication technology are necessary to support the next generation in learning and knowledge creation and sharing.

Information technology is very useful for transferring explicit, codified knowledge, but its role in the transfer of deeper, internalized knowledge is more complex. Information technology tools can facilitate knowledge transfer taking place from person to person, often in an unstructured environment, and help in creating more organized/structured knowledge. A wiki is a good example, as it can be used to collect unique experiences of personnel and organize them in a structured way, in addition to facilitating discussion. It acts as a tool to bring people together and enhance communication and allows the organized storage and transfer of unstructured thoughts and notes, etc.

2.5. INTEGRATING KNOWLEDGE MANAGEMENT INTO BUSINESS PROCESSES OR MANAGEMENT SYSTEMS

In the nuclear field, process based management systems and knowledge management are both recent developments in the management of nuclear facilities. Recent feedback from Member States has indicated that many nuclear industry organizations that have implemented process based management systems have found it beneficial to use knowledge management tools and methods to improve their management processes, rather than considering knowledge management as a separate entity. The guidance in this publication uses this approach, in which knowledge management methodologies and processes are part of an integrated management system, rather than knowledge management being a separate, standalone system [5, 6].

IAEA safety standards include provisions for knowledge management within a management system. IAEA Safety Standards Series No. GSR Part 2, Leadership and Management for Safety [7], emphasizes that “The knowledge and the information of the organization shall be managed as a resource” (Management of Resources, Requirement 9 (provision of resources)). Provided below is an example of one of these provisions in section 4.4 of the IAEA Safety Standards

Series No. GS-G-3.1, Application of the Management Systems for Facilities and Activities [8].

> "Data should be converted to information for the continual development of an organization's knowledge, and senior management should treat information as a fundamental resource that is essential for making factually based decisions and stimulating innovation. To manage information and knowledge, senior management:
>
> (a) Should identify the organization's information needs;
> (b) Should identify and access internal and external sources of information;
> (c) Should convert information to knowledge of use to the organization;
> (d) Should use the data, information and knowledge to set and meet the organization's strategies and objectives;
> (e) Should ensure appropriate security and confidentiality;
> (f) Should evaluate the benefits derived from the use of the information in order to improve the management of information and knowledge;
> (g) Should ensure the preservation of organizational knowledge and capture tacit knowledge for appropriate conversion to explicit knowledge."

Section 6.4 of this publication [8] indicates that the organization ought to consider knowledge management to be one of the areas for which the process necessary for the effective implementation of management systems needs to be developed.

Figure 5 provides a graphical representation of the manner in which knowledge management can most effectively add value to process based management systems; that is, to build knowledge management tools and methods into processes governed by the integrated management system, rather than viewing knowledge management as a separate, standalone system.

For example, if an organization wants to introduce a knowledge loss risk management process, it needs to recognize that the personnel possessing critical knowledge of the organization may be contributing to the core or managerial or support processes, or a combination of them. Therefore, the system for the assessment of knowledge loss needs to interact with any of these processes to derive information such as date of retirement and competencies possessed. The outputs generated from the knowledge loss risk management process, such as key competencies at risk, can be useful for successful and efficient functioning of any or all of the management processes.

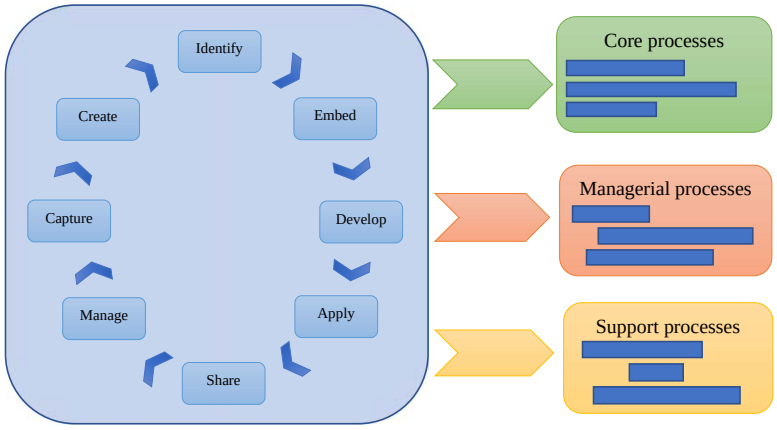

FIG. 5. Integrating knowledge management into management processes.

3. ELEMENTS OF A KNOWLEDGE MANAGEMENT PROGRAMME

Practices such as mentoring and learning from experience were in use even before the term knowledge management had been invented. They are very important and act as a foundation for establishing successful knowledge management programmes. Therefore, first, an organization's knowledge management programme needs to carefully consider and evaluate existing practices that can support its knowledge management objectives. Some of the practices being followed in nuclear organizations that have been contributing to knowledge management are described in Section 3.1. In addition to the practices listed in Section 3.1, there may be other practices in an organization contributing to the objectives of the knowledge management. The knowledge management programme ought to consider all those practices that are useful for meeting its objectives. Sometimes it may be necessary to improve or make changes to existing practices in order for them to address the objectives of the organization's knowledge management programme. For example, an organization's mentoring activities may need to be oriented to facilitate critical organizational knowledge transfer.

The next step is to identify knowledge management activities to achieve specific objectives of knowledge management. These are termed knowledge management projects, as they are executed like projects. Some of the projects implemented and the benefits they offered in achieving specific objectives in nuclear organizations are explained in Section 3.2. Depending upon the

knowledge management needs and issues faced by an organization, it may be necessary to initiate projects other than those listed in Section 3.2.

A successful knowledge management programme consists of both useful knowledge management practices and knowledge management projects aimed at achieving specific knowledge management goals, as depicted in Fig. 6.

3.1. PRACTICES THAT SUPPORT KNOWLEDGE MANAGEMENT

Over the years, the nuclear industry has reaped significant benefits by creating competent human resources and by adopting practices that furthered the successful and efficient creation and sharing of knowledge. It is important to recognize such practices in nuclear organizations and nurture them to achieve an organization's knowledge management objectives. This section explains some of the proven practices that can contribute to an organization's knowledge management programme.

3.1.1. Learning from experience

The experience and knowledge gained in the design, construction and operation of the world fleet of NPPs and nuclear facilities present a great opportunity

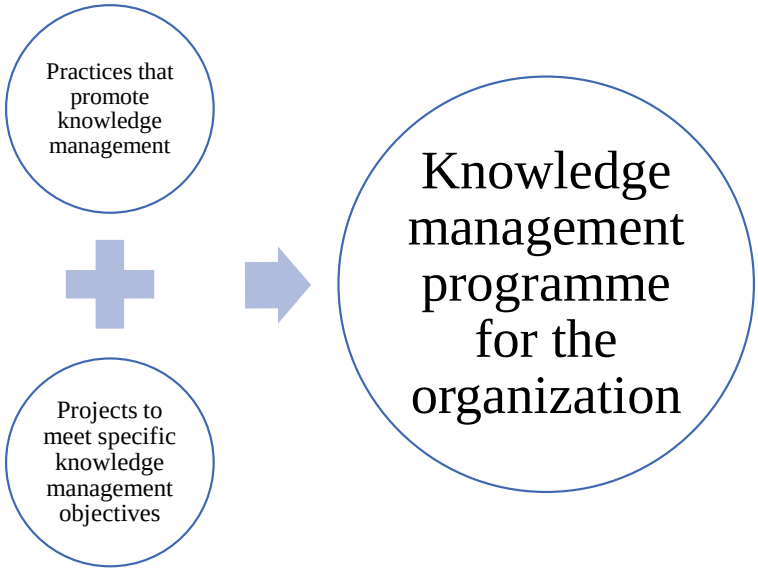

FIG. 6. Knowledge management programmes consist of knowledge management practices and knowledge management projects.

for making improvements that can bring both safety and financial benefits. Nuclear organizations use formal processes to capture, analyse and identify corrective actions from both in-house and international experiences [9]. Specially designed web portals and software applications [10] are used for this purpose and provide a platform for organizing knowledge gained through experience and lessons learned for the benefit of the organization and its personnel.

External collaborations for sharing experience and knowledge are a great opportunity in the nuclear industry. Learning from shared experiences from vendor organizations, manufacturers, technical service organizations and international organizations provides enormous benefits. For example, cooperation and membership with the IAEA, World Association of Nuclear Operators (WANO), Institute of Nuclear Power Operations (INPO) or other groups give access to large industry knowledge bases.

3.1.1.1. Mentoring and coaching

Mentoring and coaching are tools used by industry to improve the performance of employees. A mentor has experience in a particular field and imparts specific knowledge, acting as adviser, counsellor, guide, tutor, or teacher. Mentoring plays an important role in the transfer of tacit knowledge from experienced professionals to newcomers or less experienced colleagues. In contrast, the coach’s role is not to advise, but to assist the person being coached in uncovering their own knowledge and skills and help them to become their own advisers. A coach helps a staff member or a group of personnel to achieve high performance, reveal potential and find the best way to achieve expectations through observation, dialogue and imparting specific knowledge and skills. Coaching helps the organization to enhance an individual's or team's capacity, judgment and ability to act independently. It enables organizational learning by passing on the skills, routines, norms and values associated with various business processes and functions. The most significant aspect of mentoring and coaching is that it helps in the transfer of ideas and thought processes that will foster specialized skills, self-confidence and maturity.

3.1.1.2. Use of human error prevention tools

Human error prevention tools are used by the industry to improve human performance. They became a widely accepted practice in the nuclear industry as a way of promoting improved safety culture and enhancing productivity. Although the main goal of human error prevention tools such as procedure use, pre-job briefing and post-job review is to prevent human errors while executing

plant operation, maintenance and engineering activities, they can contribute to knowledge management in organizations.

In a pre-job briefing, the team involved in performing an important activity come together and discuss the critical steps involved, situations where errors may be likely and possible countermeasures just before the start of the activity. Although the focus here is on understanding risks and generating common understanding for execution, it presents an opportunity to learn from each other and provides a forum in which to exchange experiences. In particular, senior team members can impart their experiences to more junior team members. It helps promote the sharing of knowledge through personnel interaction.

The post-job review is a meeting of all personnel involved in an activity where the lessons learned — what went well and what can be done better — are discussed. Organizations capture this information or knowledge and analyse it to obtain larger benefits.

3.1.2. Competency mapping

Competency is defined as the knowledge, skill and attitude required to perform a particular role or task to a certain standard. Nuclear organizations' employees possess a variety of competencies, depending upon the roles and responsibilities assigned to them. Nuclear organizations deploy personnel to their assigned positions after ensuring that they possess suitable competencies.

Competency mapping of an organization is an involved process and it includes the following steps:

(a) Identifying the grades and levels of employees of an organization by looking through the organizational structure;
(b) Analysing the requirements for different grades and levels, identifying the job roles and competencies needed for different grades and levels of employees;
(c) Using (in some cases) a job and task analysis process to identify all the relevant knowledge, skills and attitudes necessary for a discrete task or activity to support a competence requirement;
(d) Measuring the competence level of employees using techniques such as self-assessment, supervisor/manager review or other formal processes, such as interview or questionnaire techniques;
(e) Linking competencies with employees and their roles and grades;
(f) Organizing the above information in a proper format for easy understanding and use.

Competency mapping provides the big picture of an organization's human resource capability and required competencies and helps in recruitment and selection. It can be utilized to support continued evaluation of workforce requirements and succession planning to ensure that the relevant competencies are available in the future to provide seamless staff transition and organizational change. Competency mapping may also be extended to requirements, such as outage planning or major facility renewal and long term operational projects.

3.1.2.1. Succession planning

Succession planning is a systematic approach to develop potential successors to fill identified technical or leadership positions within an organization. It involves the identification of key staff positions, potential succession candidates and developmental activities for the successor. Succession planning in organizations involves not only initiatives for leadership and management positions, but also for professional level positions and technical/subject matter experts. In succession planning, the unique skills and knowledge that an individual possesses are considered and evaluated against established data concerning organizational skills and knowledge to determine if they are critical to the organization. It is therefore linked to the strategic workforce planning of the organization. Actions are planned based on identified gaps in succession planning to ensure that the knowledge base of the organization is maintained at the necessary level. Succession planning is an important process that supports the knowledge management programme of an organization.

3.1.3. Communities of practice

Communities of practice (CoPs) is an important tool for sharing of knowledge. Personnel working in similar knowledge domains are networked through a formal or informal process. The informal networks are driven by a culture of sharing encouraged by supervisors, managers and leaders of the organization. Informal networks are usually initiated from the lower level employees and they are nurtured and encouraged by senior level management. Informal networks usually exist at department level or at a unit level. The senior members of the network share their valuable experience and knowledge and the junior members bring new ideas and thoughts to the group. Some organizations use such informal networks effectively to identify opportunities for improvement in both technical and business processes. Examples of informal CoPs are groups of technical personnel working in radiologically controlled areas of a nuclear facility. They share experiences and come out with innovative ideas to minimize

radiation exposure in plant activities. Incentives, encouragement and support from senior management can bring larger benefits from such informal networks.

Formal CoPs can also be established with a clear purpose and defined roles and responsibilities for the members. This can be done at the facility level or at the organization level. It can also be done by involving personnel from other domestic or international organizations. It is very important to have senior level organizational support to form and promote interactions. Usually the networking is done through computer based applications like wiki forums or by using a company intranet site. Organizational business and technical issues can be referred to such CoPs for resolution and decision making.

CoPs offer the advantage of utilizing collective knowledge and experience by attracting those with knowledge and experience in a particular topic or discipline. CoPs are used effectively for problem solving (e.g. engineering or technical tasks). CoPs can be dedicated to knowledge domains (e.g. instrumentation and control, turbines and generators, radioactive waste management, refuelling, training etc.). Formal CoPs can be used for the exchange of new approaches, techniques and methods between professionals.

3.2. KNOWLEDGE MANAGEMENT PROJECTS

Focused knowledge management activities will be necessary to address specific issues or to achieve a specific objective. These are usually executed as projects with a clear timeline and measurable outputs to monitor their effectiveness. The type of knowledge management project required by an organization depends on the issues it faces and its knowledge management objectives. In this section, some of the knowledge management projects successfully utilized by nuclear organizations are explained with the aim of illustrating the possibilities of exploiting similar approaches.

Table 1, created using information taken from Section 5.1 of IAEA Nuclear Energy Series No. NG-T-6.7, Comparative Analysis of Methods and Tools for Nuclear Knowledge Preservation [11], provides a list of questions that are useful to ask when selecting a knowledge management project for implementation. It provides insights into the efforts required, the challenges and the potential benefits. It is helpful to evaluate whether a particular method is beneficial to an organization, in addition to providing some useful information concerning the efforts and resources needed.

TABLE 1. KNOWLEDGE MANAGEMENT PROJECT SELECTION QUESTIONS [11]

Question	Answer
Does the given method require an external expert to implement?	Yes/no
What is the relative complexity of the implementation project effort for the given method?	Low/medium/high
What is the typical time duration needed to implement the given method?	Hours/days/months/years
What is the budget required to implement the given method?	Low/medium/high
What is the potential area(s) of impact of the given method in an organization?	Safety/performance improvement
What is the magnitude of the potential benefit to an organization of implementing the given method in the potential area(s) of impact?	Low/medium/high
What are the potential consequences for an organization of not implementing the given method in the potential area(s) of impact?	Low/medium/high
Is the implementation of the given method a one time, periodic, or continuous effort or initiative?	Yes/no
What is the risk of encountering issues or problems with the implementation of the given method?	Low/medium/high
Are changes required to an organization's work methods or procedures to implement the given method?	Yes/no
Are changes required to the organizational culture to implement the given method?	Yes/no
What is the typical level of management support required to successfully implement the given method?	Low/medium/high

3.2.1. Knowledge loss risk management

The loss of personnel possessing critical knowledge on account of retirement or other causes poses a threat to organizational performance and sustainable business activities. This issue acquires greater significance considering the fact that developing some of the key nuclear competencies is either time consuming or requires significant technical training and development. Some nuclear organizations have assessed the risk associated with the loss of key personnel quantitatively and identified methods of mitigating them.

Two approaches are involved. One approach uses a top down process in which the competencies used in an organization are mapped against its employees in a matrix format. The analysis of matrix data helps to determine the prioritized list of competencies at risk, identify important positions and detect key experts at risk. This information is assessed periodically to make adjustments to the staff recruitment programme, training and retraining programmes, staff rotation and the succession plan.

The second approach employs a bottom up process that uses an attrition risk factor (based on expected retirement or other attrition data) and a position risk factor (based on critical knowledge possessed and level of effort required to fill the position) to quantify the total risk of different positions in an organization. It is used to identify options to retain knowledge and skill in an organization, including the process of monitoring and evaluating knowledge retention plans.

The approaches complement each other. Implementation of both approaches helps organizations to identify and understand the level of risk involved in the loss of personnel possessing critical knowledge. It helps to develop short and long term strategies to mitigate the risks. The IAEA developed a publication that explains the process of knowledge loss risk assessment and provides detailed guidance for implementing this activity [12].

3.2.2. Knowledge loss risk management for outsourced activities

The knowledge required for safe, efficient and long term business sustainability may reside within the organization or may come from an external organization, as illustrated in Fig. 7. Several factors influence an organization's decision to outsource knowledge and skill, including the following:

(a) A desire to reduce the overall cost of the service to the host organization.
(b) A desire to focus on the core business, leaving non-core areas to external organizations.
(c) The high quality service required for nuclear standards may only be available in an external organization.

(d) A desire to increase the speed and in turn improve the efficiency of business processes.
(e) A desire to foster innovation.
(f) Suitable human resources may not be available within the organization.
(g) Contractual agreements concerning transfer of knowledge, including intellectual property (IP) issues, may exist.

In many cases, outsourcing brings increased economic benefits. At the same time, the risks associated with the loss of knowledge and skill with respect to outsourced activities are to be carefully considered and evaluated. In outsourced activities, it should be recognized that knowledge and skill are not the only resources at risk. The capacity to perform an activity or function may be lost through external contractors and outsourcing. Therefore, it is important that knowledge coming from external organizations such as suppliers and service providers, including engineering, maintenance, procurement and construction organizations, are identified and managed through suitable risk assessment processes. In particular, as the older nuclear facilities look to extend their operational lifetime, the loss of experienced personnel and the introduction of outsourced organizations to fill these gaps requires careful consideration and risk management. The IAEA developed a publication concerning quantitative risk assessment of outsourcing activities in NPPs that provides guidance for

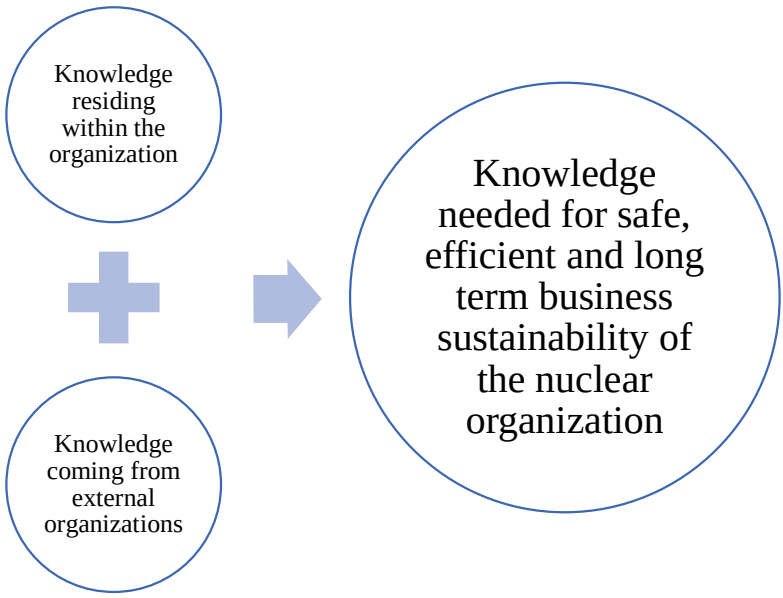

FIG. 7. Sources of knowledge for a nuclear organization.

the implementation of an appropriate knowledge management strategy; refer to IAEA-TECDOC-1884, Knowledge Management Perspectives on Outsourcing in Operating Nuclear Power Plants [3].

3.2.3. Knowledge management initiatives to transfer tacit knowledge

A number of approaches and methods are used to identify and recover knowledge acquired by experienced individuals who have a few months or years of service remaining before retirement or before they leave the organization or job position for some other reason. Organizations use techniques such as video recording, elicitation interviews, storytelling, task observations, concept mapping and process mapping to extract knowledge and skills in such situations. The tools selected for use depend upon the type of knowledge and skill possessed by the individual. New or improved procedures, job guides and experience reports are generated based on information gathered through this process.

Knowledge transfer techniques such as mentoring, coaching and shadowing practices are important tools that are often built into an integrated technical succession planning process within an organization to ensure that a more systematic process is in place to support the transfer of knowledge.

A well planned and implemented proactive approach is the backbone of a successful knowledge management programme. A knowledge loss risk assessment programme, as explained in Section 3.2.1, needs to be well supported by a structured knowledge transfer programme to mitigate risks.

The techniques for knowledge transfer mentioned in this section require guidance and experts who are experienced in using the techniques.

3.2.4. Knowledge portals and information technology platforms for knowledge management

Knowledge portals typically provide a single, often personalized, interface for accessing and consolidating information from different sources. Typical resources that are accessible via a knowledge portal are technical documents, databases of experts, operational experience information, performance metrics, portal of communities of practice, etc. In addition to hosting valuable information resources, the portal is used for the execution of key facility functions that use the documented knowledge of the portal. Examples include work management system and the configuration management system of NPPs.

An efficient search engine is an essential component of a portal, allowing users to find internal (and sometimes also external) content. A knowledge portal additionally provides a topical structure, often in the form of a taxonomy, through

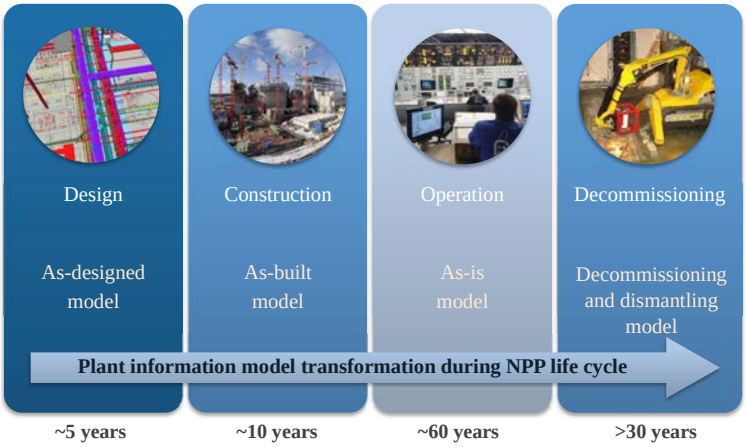

FIG. 8. Schematic diagram for a plant information model.

which content can be tagged, knowledge pages structured and enriched, and search quality enhanced (semantic search).

With advances on the information technology front, nuclear organizations have developed customized portals and platforms for the benefit of knowledge management. This reduces the time taken to access necessary information, provides a platform for managers and leaders to access key performance metrics and facilitates decision making by providing easy and structured access to knowledge. Refer to IAEA Nuclear Energy Series No. NG-T-6.2, Development of Knowledge Portals for Nuclear Power Plants [10] for more information.

With advancements in information technology, nuclear organizations use applications such as plant information models or building information models to create facility designs using three dimensional computerized drawings and animations. In addition to providing clear and easy to understand visuals of plant structures, systems and components, these models host a significant amount of information in a format that is easy to understand, retrieve and use. Some examples of the information hosted include plant process and instrumentation diagrams, construction drawings, equipment and facility design specifications and operational procedures, together with much more information that is required throughout the plant life cycle phases. This type of application allows the capture of design and engineering changes being implemented as the facility moves through different life cycle phases, such as construction, commissioning and operation until decommissioning. Therefore, it becomes a living source of knowledge for the facility personnel. Figure 8 illustrates the concept of a plant information model.

Organizations use these information technology enabled technologies to leverage knowledge management practices. Depending upon the goals of the

organizations, these tools can be exploited for the benefit of knowledge transfer and management:

(a) Wiki platforms provide a structure to organize and share knowledge efficiently, bringing together experts to share their knowledge and experience for the use of others who may need them. The IAEA manages one for the decommissioning community called the IDN Decommissioning Wiki [13], in which experts around the globe share information for the benefit of a larger decommissioning society.
(b) Learning management systems facilitate the creation, delivery and management of interactive e-learning courses. Nuclear organizations use such platforms for the delivery of both on-line training courses and a combination of on-line and face to face training called blended learning. These platforms provide flexible, efficient and cost effective training. The IAEA's Computer Learning Platform for Network Education and Training (CLP4NET) is a learning management system created for the purpose of promoting e-learning.

4. DEVELOPING STRATEGIES FOR KNOWLEDGE MANAGEMENT

The strategy to introduce a knowledge management programme, set in line with the organization's business objectives, usually starts at the organizational level, involving all key stakeholders within the organization.

The practice of knowledge creation, transfer, sharing and promotion is closely connected with the education, training and HRD activities used to develop competent individuals and teams within an organization. The successful execution of knowledge based plant activities depends significantly on the education, training and HRD programmes of the organization. The knowledge based activities in nuclear organizations are significant and play an important role in developing knowledge management strategies and programmes.

A knowledge management strategy needs to carefully consider the connection between education, training, HRD and knowledge activities, as represented in Fig. 9.

A knowledge management programme is more likely to be successful if there is a clear strategy and set of underpinning objectives of benefit to the organization. The first step in developing a knowledge management strategy is to define the problem to address. To accomplish this, an assessment of current nuclear knowledge in the organization ought to be conducted and compared

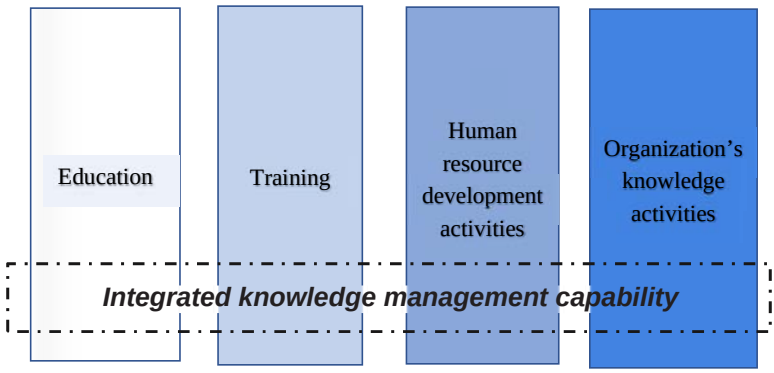

FIG. 9. Integrated knowledge management capability.

with an assessment of the knowledge that is needed for effective, safe, efficient and sustainable organizational performance. The following are examples of assessment questions that may apply:

(a) Is there a risk of losing critical knowledge due to attrition (e.g. retirement from an ageing workforce)?
(b) Should the organization develop current human resources to improve performance and bridge the knowledge gap to address challenges and maintain competitive edge?
(c) Does the organization need to develop educational and training systems to meet future needs?

There are many tools for assessing the maturity of knowledge management. The IAEA has developed a model approach for conducting a quantitative self-assessment of knowledge management maturity in nuclear organizations [14]. Using this approach or another one means that an organization needs to assess its current status as compared to the desired state to assist in strategy development.

Once an understanding of the current state has been assessed, a clear approach and a strategy can be developed. A simplified approach for elaborating a knowledge management strategy is presented in Fig. 10.

The following approaches may be considered to develop a knowledge management strategy:

(a) Top down: the overall strategic direction of the organization is used to identify the focus of the knowledge management initiative. The activities planned under a knowledge management programme reflects this broad goal.

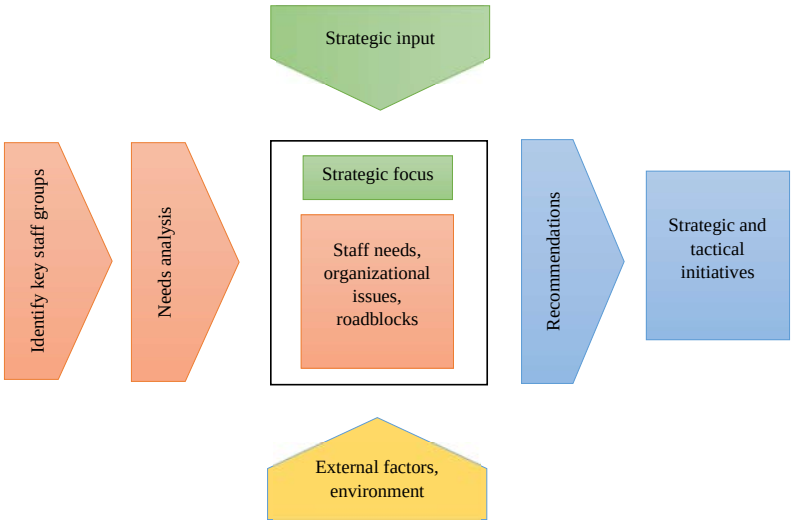

FIG. 10. An approach to developing a knowledge management strategy.

(b) Bottom up: the first step is analysis of the activities of staff involved in key organizational functions/activities, with a focus on identifying knowledge management issues and needs. This is followed by the initiation of a range of knowledge management activities/projects to alleviate the issues and meet the needs.

(c) Reactive: knowledge management initiatives are based on perceived needs arising from risk analysis, lessons learned, trend analysis, staff/stakeholder feedback, changes in external environments, changes in regulation, benchmarking with other organizations, etc.

Each of these approaches has its strengths and, in practice, a successful knowledge management programme has to encompass elements from all of them.

4.1. ELEMENTS OF THE KNOWLEDGE MANAGEMENT STRATEGY

The strategy ought to be positioned at a high level and focus on setting organizational knowledge goals that address organizational needs utilizing strategic methods. Strategy will typically highlight leadership, integration and sponsorship, and outline objectives to provide a framework for the subsequent development of projects to deliver tangible benefits. The strategy ought to be adopted at the highest corporate level, usually by the executive, in order to establish the cross-cutting support, multifunctional buy-in and potentially

significant cost elements that may be required to implement meaningful change in an organization. The strategy ought to prioritize knowledge management activities that align with the organization's business goals and yield the greatest benefits for the organization, whether that is improved safety, security, efficiency or regulatory/statutory/contractual compliance, or, most likely, a combination of these.

The objectives of the knowledge management strategy ought to be aligned, from the very beginning, with the organization's strategic direction. A careful review of corporate strategies/programmes with due consideration for knowledge management elements will reveal ideas for setting high level objectives for a knowledge management strategy. Areas to focus on for identifying the objectives include:

(a) Discussions with decision makers/executives;
(b) Review of annual reports, performance reports and business plans;
(c) Human capital issues (workforce demographics, HRD needs);
(d) Stakeholder issues (government bodies, customers, technical support organizations);
(e) Social issues (public acceptance);
(f) Identification of known risks from risk registers/trend analysis, etc.

The attributes of an effective knowledge management strategy include:

(a) Knowledge is recognized by all as an asset that requires acquisition, support, maintenance, management and disposition;
(b) Knowledge management activities are recognized and supported throughout the organization, and in particular, are sponsored and led on at the executive level — managers lead by example;
(c) Knowledge requirements are identified along with other key resources such as plant systems, structures and components, and finances and managed with the same attention;
(d) Knowledge resources are the responsibility of nominated senior managers who have the resources and influence to ensure that they are maintained and made available — they also have responsibility for ensuring the continued availability of these resources;
(e) Knowledge management activities are embedded in functional and operational processes so that they become part of 'business as usual';
(f) Knowledge management activity is focused on meeting institutional goals with clear objectives to improve safety, security, financial return, efficiency and compliance;

(g) Knowledge management activities need to be specific, measurable, achievable, realistic and timely (SMART);
(h) Knowledge management philosophy has permeated throughout the organization and also the stakeholders, regulators, technical support organizations and supply chain;
(i) Valuing, sharing, managing and maintaining knowledge is 'what we do' — it is part of the corporate culture;
(j) Adequate resources are applied continually to ensure that knowledge is created, captured, identified, embedded, developed, applied, shared, managed and renewed;
(k) Information technology and technology/applications are recognized as potentially important to deliver knowledge programmes efficiently.

4.2. PERFORMANCE MONITORING OF KNOWLEDGE MANAGEMENT PROGRAMMES

Given the cross-cutting nature of nuclear knowledge, its longevity, and its tacit and socially distributed nature, effective measuring systems are often difficult to envisage and implement. Some knowledge management initiatives will produce intangible knowledge assets with a value that is often very difficult to conceptualize and communicate. The implementation of knowledge management projects and programmes is generally supported by anecdotal evidence concerning successful delivery. However, it is becoming increasingly important and necessary to provide hard evidence of knowledge management benefits to senior managers and other stakeholders inside and outside the organization. This section provides guidance on the selection and use of performance indicators to assist knowledge management practitioners and is applicable to wide ranging knowledge management programmes as well as individual knowledge management projects.

4.2.1. The importance of measuring knowledge management performance

Knowledge management initiatives require measurements to be made to ensure successful delivery and realization of benefits. The most common reasons why knowledge management performance ought to be measured and key performance indicators (KPIs) established are:

(a) Gathering evidence to demonstrate performance improvement or the success of a particular knowledge management initiative;
(b) Monitoring progress (i.e. time, cost) of knowledge management initiatives;

(c) Learning from experience and continuous improvement;
(d) Detection or mitigation of potential knowledge management implementation problems;
(e) Benchmarking knowledge management performance against that of others (internal versus external).

The selection, data collection and presentation aspects of KPI implementation are important.

4.2.2. Selecting key performance indicators

In selecting what to measure, a number of factors need to be considered. The most important requirements for selection are that it ensures that KPIs:

(a) Have a clear link to the organizational strategy and objectives and cover the main areas of benefit addressed by the knowledge management business case.
(b) Cover a range of benefits at different levels from the knowledge management initiative itself (e.g. as a project) through to the organizational benefits to be realized from the initiative (see Section 4.2.3).
(c) Contain a mix of parameter types:
    (i) Quantitative and qualitative;
    (ii) Leading/lagging indicators.
(d) Are relatively easy to understand and obtain.
(e) Consider stakeholders' needs (e.g. other business units, customers, the regulator, suppliers) and their involvement in the knowledge management initiative.
(f) Are proportionate to the complexity of the knowledge management initiative, its cost and its benefits.
(g) Address both long and short term needs; some knowledge management initiatives may be short lived and eventually closed down, while others may exist permanently throughout the lifetime of the organization.

4.2.3. Relationship with the line of sight model

The line of sight model is described in IAEA-TECDOC-1675, Knowledge Management for Nuclear Research and Development Organizations [15] and is used to link knowledge management tools and techniques to the organizational benefits sought. This model can also be used to identify the levels of KPIs to be put in place for each knowledge management initiative. Typically the KPI structure is set up so that KPIs will be implemented at three levels — the organizational

benefit level, the knowledge management driver level and the knowledge management tool level. This ensures that the knowledge management initiative is managed with a clear focus on the benefits sought, as depicted in Fig. 11.

4.2.4. Gathering key performance indicator data

The data and information relating to the chosen KPIs need to have the following characteristics:

(a) From a reliable source and readily available in existing information systems from the financial, human resource or other similar units or functions within the organization;
(b) Regular and time dependent trending data with time is useful as it shows how the KPI is progressing and whether real progress is being made;
(c) Simple and representing the measure needed to demonstrate success; parameters derived from various data sets are often subject to subjective interpretation and as such may not represent the true picture.

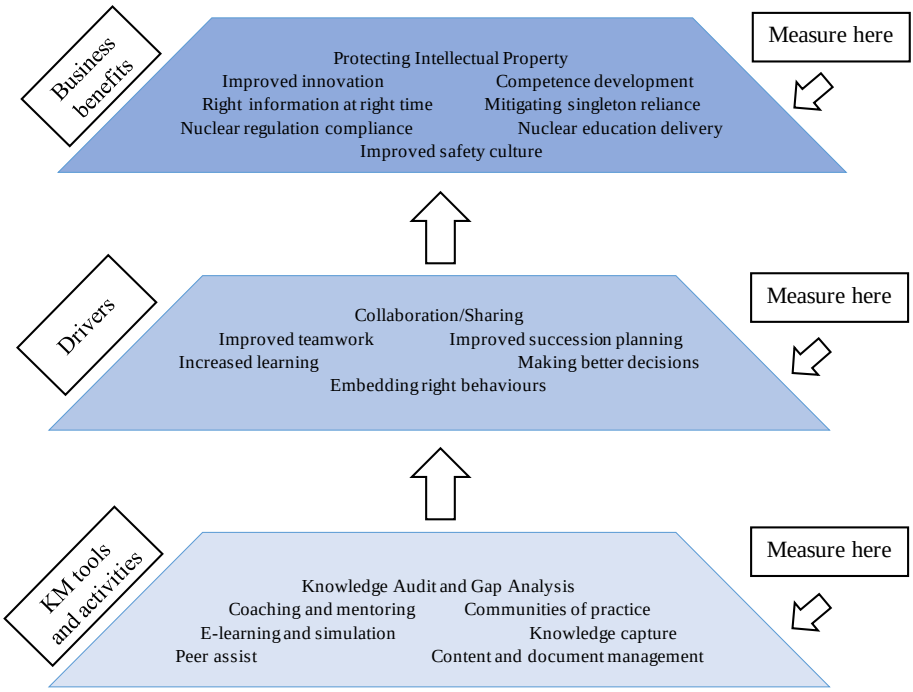

FIG. 11. Line of sight model — linking knowledge management tools and activities with organizational benefits.

4.2.5. Presentation of key performance indicator data to senior management

Key performance indicator data ought to be presented to senior management in a clear concise manner, emphasizing the benefits of the knowledge management programme or initiative. This aspect ought to be a regular agenda item when discussing the initiative with senior management as part of the routine and regular management reviews of the organization.

4.2.6. Examples of key performance indicator derivation

The following examples demonstrate the KPI selection process as applied to typical knowledge management initiatives. The examples are not exhaustive, and practitioners are advised not to accept the guidance verbatim, but to explore their own needs.

4.2.6.1. Example 1: Knowledge loss risk assessment and capture of knowledge from subject matter experts

This is a typical knowledge management initiative that many nuclear organizations are applying. It involves an initial risk analysis to identify key experts, followed by elicitation interviews and other techniques to help capture and transfer knowledge.

For this initiative, the following six KPIs are proposed.

The following KPIs are for the project level:

(a) The number of experts who have completed the elicitation process (simple measure of progress with time);
(b) Project spending versus budget (financial measure to demonstrate cost/benefit in the business case);
(c) Elapsed time to complete per expert (provides useful insights at the beginning of the project to help determine the total time to complete).

The following KPIs are for the intermediate level:

(a) Progress (% completion) against all knowledge retention/transfer plans (this parameter indicates how well the experts' knowledge is being transferred to others and actions are taking place to do this);
(b) The number of successors in place, achieving minimum competence level (simple measure that the succession planning process is working).

The following KPI is for a higher level:

(a) Risk/reliance on key experts (this is a subjective risk based parameter measured at corporate level concerning the risk to the organization of disruption to the business caused by loss of key experts; some organizations may not be measuring this aspect as part of the overall corporate risk strategy).

4.2.6.2. Example 2: Implementation of communities of practices within a large organization

This typically involves setting up groups of employees with a common interest and using face to face and on-line collaboration tools to help share knowledge and address issues or problems within the community. CoPs create value by bringing together expert resources and creating knowledge assets, and so many of the benefits are intangible and difficult to measure directly.

For this initiative, the following seven KPIs are proposed.

The following KPIs are for the project level:

(a) The number of CoPs established per month/quarter with available terms of reference;
(b) Project spending versus budget;
(c) The number of staff engaging in CoP activities (simple measure of total numbers or % of staff signed up to and actively involved in the activities of the CoP);
(d) The number of CoP closures (much later in the programme some CoPs will reach the end of their useful life and will cease to add value; it is important that these do not act as a drain on staff resources, money and time).

The following KPIs are for the intermediate level:

(a) The number of knowledge assets produced (the number of artefacts (e.g. drawings, documents, products) the CoP has produced that have been applied to specific business needs; these will depend on the nature of the CoP and its purpose);
(b) The number of case studies produced by each CoP describing the benefits from its work (case studies tell the story of how the CoP has successfully helped others achieve business objectives).

The following KPI is for a higher level:

(a) CoP satisfaction (qualitative data gathered on the experience, perceived benefits and other feedback to the organization; this may also be part of a general employee satisfaction survey).

5. GUIDANCE FOR KNOWLEDGE MANAGEMENT IMPLEMENTATION

This section provides guidance for the implementation of a strategic knowledge management programme. Figure 12 outlines the seven key steps for successful implementation. The steps are applicable for any nuclear organization. Figure 12 can be used as a roadmap for implementing knowledge management programmes in nuclear organizations.

FIG. 12. Knowledge management roadmap.

5.1. ORIENTATION AND AWARENESS

The first step in implementing a knowledge management programme starts with creating orientation regarding and awareness of both knowledge management concepts and the programme's benefits to all stakeholders in the organization. The orientation needs to introduce practical examples of how knowledge management can increase organizational performance in both the safety and financial domains.

The IAEA, upon request, provides assistance to Member State organizations to create orientation and awareness through a knowledge management assist visit level 1 [14]. The mission introduces existing industry good practices for knowledge management methodologies and approaches. The topics typically covered in these orientation workshops include the following:

(a) Definitions for and introduction to knowledge management concepts and terminologies;
(b) Competency mapping and succession planning;
(c) Knowledge management practices and knowledge sharing culture — lessons learned;
(d) Knowledge loss risk management;
(e) Knowledge management perspectives on outsourcing for nuclear organizations;
(f) Information technology portals and information management systems for knowledge management;
(g) Planning and implementing a knowledge management programme;
(h) Integrating knowledge management into organizational business processes;
(i) Other topics to assist the introduction of a beneficial knowledge management programme;
(j) Introduction to the IAEA's knowledge management maturity assessment methodology.

Creating a sense of ownership for knowledge management activities among stakeholders is essential for the success of the knowledge management programme. In many organizations, human resources or training departments take the lead in implementing knowledge management programmes. The role of technical departments and their participation are significant for the success of knowledge management programmes. Therefore, the orientation plan should include strategies to engage all key stakeholders.

5.2. ANALYSIS OF SAFETY REQUIREMENTS AND BUSINESS NEEDS

This step involves identifying the issues of the organization for which knowledge management could be a solution. The issues may be connected to meeting safety or regulatory requirements or providing improved/sustainable business performance. This involves understanding the risk associated with these issues, prioritizing them and analysing the potential solutions and benefits. A thorough analysis of the organization's performance metrics and anticipated potential constraints for future business will reveal critical issues for which knowledge management could be a solution. The analysis may extend to different areas of the organization, depending on the type of organization and its reasons for initiating a knowledge management programme. The following list states some possible important sources of information for the analysis:

(a) The results of risk and gap analyses performed for various programmatic areas of the organization.
(b) Analysis of events, incidents and their trends. Analysing the events in the station operating experience database for events and incidents related to shortfall in knowledge management and its related areas. The goal may be to achieve gains in economics and operational performance.
(c) Needs identified for innovation and business development.
(d) Competency mapping and/or succession planning programmes, where organizations have them. These can be used as a feeder for developing activities for knowledge management programmes.
(e) Surveys and questionnaires focused on identifying knowledge management needs.
(f) Needs identified for the protection of sensitive knowledge (e.g. sensitive security, safeguarding and IP issues).
(g) Needs identified for the transfer of knowledge to the next generation.
(h) Needs identified for the transfer of individual knowledge and experience to organizational knowledge.
(i) Requirements related to the retention, validation and verification of knowledge, experience and data, including big data sources (e.g. basic and detailed design data), from the perspective of long term needs during the entire life cycle of a facility.
(j) Identified knowledge at risk and experts at risk from the knowledge loss risk point of view.
(k) Inputs from analysis of trends of market behaviour from the perspective of the organization's needs (e.g. labour market, educational system changes).

The IAEA has developed a knowledge management maturity assessment tool [14] to identify gaps in the knowledge management activities of an organization. The tool uses a set of statements to objectively assess the knowledge management gaps in the following eight areas:

(a) Policy and strategy for knowledge management;
(b) Human resource processes for knowledge management;
(c) Training and competence development for knowledge management;
(d) Methods, procedures and documentation processes for improving knowledge management;
(e) Technical solutions for knowledge management;
(f) Approaches for the capture/transfer of knowledge;
(g) Organizational culture to support knowledge management;
(h) Internal/external collaboration for knowledge management.

This tool allows organizations to perform self-assessment of their current knowledge management activities with respect to their desired goals. The participation of all key stakeholders in knowledge management and their ownership and commitment to this assessment is essential for successful assessment. An experienced senior person from the organization who has good understanding of the organization and knowledge management concepts ought to lead and facilitate the assessment. The IAEA, upon request, provides assistance to conduct self-assessment as part of a knowledge management assist visit level 1 [14].

The output of this step ought to identify gaps in knowledge management and the benefits of closing them.

5.3. KNOWLEDGE MANAGEMENT POLICY AND STRATEGY DEVELOPMENT

Guidance for developing strategies to establish a beneficial knowledge management programme is outlined in Section 4 of this publication. Using this guidance, taking input from the gaps identified in previous step and selecting the right knowledge management practices, projects and approaches from those described in Sections 3.1 and 3.2, the organization can put together a knowledge management policy and develop strategies that will underpin future activities. This step also can identify the higher and intermediate level KPIs described in Section 4.2.6.

The output of this step can identify a list of knowledge management practices and projects, higher and intermediate level performance indicators,

priorities, timelines, responsible lead agencies and key stakeholders, budgets and a strategic plan for implementation and monitoring.

5.4. DESIGN AND LAUNCH

In this step, actions for implementing the knowledge management practices and projects identified in the previous step are designed and developed. For example, one of the strategic plans could be to expand the existing practice of mentoring into a formal organization wide practice. Actions could include the identification of suitable mentoring programmes for different departments, the identification of mentors and mentees, the identification of actions with timelines, the establishment of project level KPIs (refer to the guidance available in Section 4.2.6), the establishment of orientation training for mentors and mentees and establishment of a system of recognition and rewards. The actions identified need to be integrated into the organization's business processes and the implementation needs to follow a change management process.

The planning and implementation of knowledge management projects intended to achieve specific knowledge management objectives ought to follow a project management protocol. The projects ought to be executed by a team headed by a project manager. The team may need to interact with other stakeholders for implementation. Successful knowledge management project implementation requires a number of prerequisites to be in place at the start. A project specific plan ought to be developed describing the project objectives together with a plan that indicates tasks, timelines and resource requirements. It should have clear start and end dates, and monitoring points for periodic reviews. KPIs (refer to the guidance available in Section 4.2.6) need to be identified in advance for both periodic monitoring and for ensuring the realization of the final objectives.

At the end of this step, the identified knowledge management practices and projects are implemented. It is not practicable to implement all planned activities at the same time. Therefore, this step may take several months to implement, depending on the number of activities planned and their intensity.

5.5. EXPAND AND SUPPORT

Sometimes, it is prudent to start a knowledge management initiative as a pilot project and later expand it in light of the feedback and experience gained from the pilot stage. In some cases, knowledge management practices and projects are implemented in a phased manner to suit organizational needs.

It is important to monitor the progress of various knowledge management practices and projects through analysis of identified KPIs and feedback from involved personnel and make necessary adjustments to the implementation plan. The success of knowledge management initiatives often depends on the quality of person–person interactions and organizational culture. Therefore, it may be necessary to have periodic training and targeted communication through routine briefings, posters, webinars and intranet portals. Senior managers and key stakeholders in the knowledge management initiatives ought to observe and motivate personnel to achieve desired changes, particularly behavioural changes. The key elements of this step are:

(a) Review of progress and adjustment of the plan;
(b) Sponsorship, leadership and support of top managers and leaders;
(c) Motivation and communication.

5.6. INSTITUTIONALIZE KNOWLEDGE MANAGEMENT

As an organization implements new knowledge management initiatives, it is important to sustain those practices and prevent the degradation of improvements. It takes considerable time and effort to institutionalize knowledge management practices in an organization. Periodic monitoring and support from managers and leaders of the organization, as well as the participation of all stakeholders, are crucial for the sustainability of the practices. A system for rewarding good work done by personnel has been found to be an effective way of promoting knowledge management practices.

As time moves on, it may be necessary to make changes in knowledge management programmes as a result of changes in the business environment, the arrival of new or changed legal/regulatory requirements, and as new options become available through technological innovations. Therefore, periodic reviews/assessments need to consider these needs and recommend changes to the programme.

In this step, the employees of the organization realize the benefits of knowledge management practices and projects. They become accepted practices and part of the culture of the organization.

5.7. EVALUATION AND CONTINUOUS IMPROVEMENT

The final step is to assess the results and outcomes of the knowledge management programme and identify opportunities for improvement. There are two ways to do this. One way is to review the identified KPIs. The assessment should

look at achievements at the overall programme level and at each activity or project level. This assessment identifies gaps with respect to the goals set in Sections 5.2 and 5.3. Detailed cause analysis ought to be conducted to identify the causes of and contributors to these gaps, followed by targeted actions to close the gaps.

The other option is to identify opportunities for further improvement. This is usually done by conducting a knowledge management maturity assessment using experts in the field. The IAEA, upon requests from Member States, provides support in conducting maturity assessments using the methodology described in IAEA-TECDOC-1880, Planning and Execution of Knowledge Management Assist Visits for Nuclear Organizations [14]. This service is provided through knowledge management assist visits level 2. Figure 13 describes the path of travel for an organization from implementing knowledge management as a localized initiative to reaching a stage of knowledge management that is embedded in the management systems or business processes of the organization.

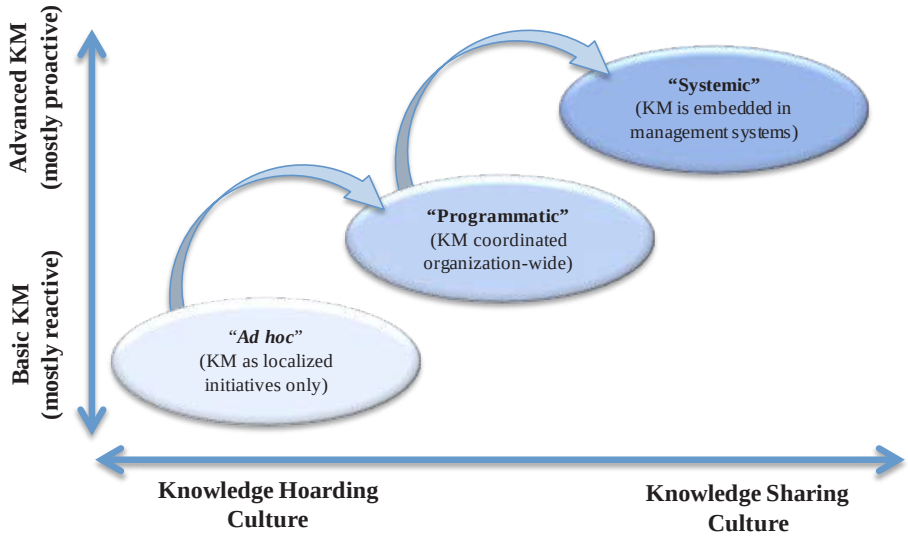

FIG. 13. Knowledge management (KM) maturity model.

6. CHALLENGES FOR THE IMPLEMENTATION OF KNOWLEDGE MANAGEMENT PROGRAMMES

This section describes the barriers or impediments to the successful implantation of knowledge management programmes. Before embarking on a knowledge management programme, it is important to understand these challenges and consider mitigative actions to overcome them during implementation. The challenges faced include the following.

6.1. ORGANIZATIONAL CULTURE

To succeed, knowledge management needs to emphasize the management of human relationships. Such relationships are themselves a function of the organizational culture. While there is no doubt about the necessity of implementing cutting edge technical solutions for a successful and efficient knowledge management programme, motivating people to contribute to the knowledge management programme and share their know-how is an important factor for success. Unless the employees of an organization are motivated to share, no information technology solution can help in achieving the desired objective. A fundamental barrier to motivating people to participate in knowledge management efforts is corporate culture, which, in some cases, creates silos in people's working styles. Reducing the impact of these silos is an important step in promoting knowledge sharing.

6.2. ORGANIZATIONAL OWNERSHIP

6.2.1. Leadership

Lack of leadership support and managerial direction in terms of clearly communicating the benefits and values of knowledge sharing practices can contribute to ineffective implementation of a knowledge management programme.

6.2.2. Structure

It is difficult to say which organizational structure is most suitable, but it is important to consider the specific characteristics of a company. However, departments working in silos usually do not support knowledge sharing. Developing a clear line of sight to the organizational characteristics will help

determine the proper organizational structure to support knowledge management. Knowledge transfer occurs through vertical chain of command in traditional hierarchical management structures. However, horizontal knowledge transfer, which needs to cross the organization's functional boundaries, is inhibited. To overcome this, organizations develop knowledge teams composed of knowledge workers from cross-functional areas towards developing a fully distributed knowledge transfer system (both vertical and horizontal) within the organization. Cross-functional team members provide knowledge sharing from their knowledge team back to their original functional areas.

6.2.3. Governance and oversight

Governance is how overall oversight and management of knowledge management programmes are achieved. Organizations follow different approaches to providing governance and oversight for knowledge management programmes. Usually, this is done through a high level steering committee, with representatives from across the organization, including senior business managers, a knowledge management business 'sponsor', one or more knowledge management 'champions' and the chief knowledge officer (or equivalent). They are the group that reviews and approves the knowledge management strategy, the priority projects and the knowledge investments, and reviews (typically on a quarterly basis) progress against objectives and plans. Without a governance and oversight structure, knowledge management programmes may not achieve their desired results or not be fully integrated into the business processes.

6.3. TECHNOLOGY

6.3.1. Information technology tools

Evolution in modern information technology technologies helps to leverage the benefits of knowledge management programmes. Sometimes information technology can become a barrier if it is inadequate or insufficiently accepted by personnel. Information technology tools themselves are not always the ultimate solution in a successful knowledge management programme. However, without suitable information technology tools, successful implementation of a knowledge management programme may not be achieved.

6.3.2. Information technology infrastructure

Not having suitable information technology infrastructure can become an impediment to a successful knowledge management programme. In addition, there is an ongoing requirement for capacity addition, training and knowledge transfer as new information concepts, infrastructure and systems appear in the industry. While it is impossible to predict developments in information technology, stakeholders can nonetheless manage the risk by adopting an information technology architecture that manages change and leaves them with maximum opportunity to adapt.

6.4. BUSINESS PROCESS STANDARDIZATION

Established organizational processes for managing core and support functions play key roles in implementing successful knowledge management programmes as knowledge management elements, in order to be sustainable, are embedded in these processes.

Having non-standard business processes that vary between organizational units can lead to ineffective knowledge management programmes, as non-standard processes based on relationships may not be effective across the organization.

6.5. HUMAN RESOURCES

Aligning knowledge management with an organization's human resource processes and training programmes will help build a learning organization with the appropriate culture of knowledge sharing. New employees will be introduced to the organization's knowledge processes and procedures and understand how to use them in their newly appointed roles. IAEA Nuclear Energy Series No. NG-G-2.1, Managing Human Resources in the Field of Nuclear Energy [16] provides guidance and support on this subject.

In practice, this brings together human resources, training and knowledge management programme managers and owners in order to determine strategies and support the alignment of workforce plans, including training to meet the organization's needs. Without this alignment, successful implementation may be jeopardized. Other human resources related aspects to consider when implementing a knowledge management programme are as follows.

6.5.1. Rewards

Not having an established rewards and recognition programme for knowledge sharing can create a culture contrary to the objectives of a knowledge management programme.

6.5.2. Generational workers

The life cycle of a nuclear facility represents at least three generations of nuclear workers whose education, experience and knowledge need to be captured, validated, preserved and passed on from one generation to the next. Such a process of knowledge preservation and turnover, together with multigenerational staff requirements, will require a sustainable, long term programme that can span several project phases, iterations and changes of management, and even changes in commercial ownership or national regulatory control.

6.6. INTELLECTUAL PROPERTY — LEGAL OWNERSHIP

Knowledge has value to the organization. It supports the goals of safety, security, competitiveness and position in the industry. IP is an important form of organizational knowledge that serves to create, store, transfer and use another's knowledge in addition to serving as a protection tool. An organization's knowledge management programme needs to consider the protection of its knowledge, and also its valuation, negotiation, commercialization and use as an organizational asset. When developing a knowledge management programme, having a clear understanding of the organization's intellectual property is a key requirement. Managers within nuclear organizations need to be aware that implementation of an intellectual property initiative can create barriers or constraints for knowledge sharing. Additional information can be found in IAEA-TECDOC-1675, Knowledge Management for Nuclear Research and Development Organizations [15].

6.6.1. Security and safeguards

Sensitive security, safeguards and other intellectual property knowledge may be divulged inappropriately, or the distribution of useful knowledge may be constrained by inappropriate application of security and safeguards techniques. Clarification and codification of sensitive information and keeping it separate from more general knowledge may provide an adequate solution. Informing and educating staff and stakeholders of the requirements and only applying 'need to

know' principles to sensitive information, while recognizing the need to share as being equally important, may assist with this.

6.7. EXTERNAL ENVIRONMENT FACTORS

6.7.1. Talent pool availability

Talent pools are typically set up by companies or organizations to help ensure an adequate supply of human capital for the organization. Key elements to ensuring a sustainable human capital programme are both internal and external talent pools. Without understanding an organization's talent pool and talent supply strategy, an organization's knowledge management programme may be less effective in achieving its long term objectives.

6.7.2. Educational infrastructure

The role of education is to help employees with the ability to become competent members of nuclear industry organizations. This also includes successfully completing the necessary industry and job specific training programs. Having a well defined educational and training infrastructure supports a nuclear organization to establish talent pools for future organizational needs. Nuclear industry managers, together with government leaders, ought to establish relationships and partnerships with relevant academic institutions, professional organizations and international organizations. IAEA Nuclear Energy Series No. NG-G-2.1, Managing Human Resources in the Field of Nuclear Energy [16] provides guidance on this subject.

7. SUMMARY

As an employee starts working for an organization, he or she gains knowledge, experience and skill over the years. Some of this is strategically important for continued organizational performance. The success of a strategic knowledge management programme depends on the ability to convert the knowledge, experience and skill possessed by the individuals of the organization into organizational knowledge and assets.

This publication, based on experience gained from knowledge management activities conducted by the IAEA over the years, provides guidance for developing

and implementing a strategic knowledge management programme. Nuclear organizations interested in introducing a strategic knowledge management programme can benefit from using the guidance given in this publication. The useful points to note for the purpose of developing and implementing a knowledge management programme are:

(a) Develop strategies to introduce a beneficial knowledge management programme using the guidance provided in Section 4;
(b) Formulate knowledge management programmes using both organizational practices that promote knowledge management (examples are given in Section 3.1) and knowledge management projects (examples are given in Section 3.2) aimed at addressing specific issues or objectives;
(c) Use guidance in the form of the roadmap provided in Section 5 to implement knowledge management programmes;
(d) Beware of the challenges for the implementation of knowledge management programmes listed in Section 6.

The information provided in Section 4.2 provides guidance for monitoring the effectiveness of knowledge management programmes. It is a useful tool for senior managers and leaders to monitor the effectiveness of knowledge management programmes.

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GLOSSARY

The following definitions apply specifically to the field of knowledge management. Identical terms applied to, or used in, other fields may have somewhat different definitions.

after-action review. A process that involves conducting a structured and facilitated discussion after a task or project has been completed to review what ought to have happened; what actually happened; and, where differences exist, why it happened. (See also *post-job briefing*.)

Comment: after-action review allows participants to learn how to sustain strengths and improve on weaknesses in subsequent tasks or projects. It is used to help teams to learn quickly from their successes and failures and share their learning with other teams.

attrition. The decrease in the number of employees in an organization as a result of retirement, other termination or transfer to other organizations resulting in a significant reduction in the organization's knowledge base.

champion. A person who proactively promotes something with the aim of persuading others of its benefits.

chief information officer. A senior position with strategic responsibility for information management and information technology.

chief knowledge officer. A senior position with strategic responsibility for promoting and implementing knowledge management.

coaching. A relationship between more experienced individuals and less experienced individuals designed to enhance learning and performance of both individuals and teams, typically focused on the achievement of specified objectives within given time frames.

codification. The process of converting people's knowledge into a form that enables it to be communicated independently of those people.

communities of practice. A voluntary group of peer practitioners who share lessons learned, methods and best practices in a given discipline or for specialized work. The term also refers to a network of people who work

on similar processes or in similar disciplines and who come together to develop and share their knowledge in that field for the benefit of both themselves and their organization(s).

competence (competency). A combination of knowledge, skills and attitudes in a particular field, which, when acquired, allows a person to perform a job or task to identified standards. Competence (competency) may be developed through a combination of education, experience and training. The term 'competency' is also used for a generic task or a function (e.g. for nuclear facility manager jobs).

competency management. Management of the competencies of the workforce to ensure that the required KSAs are identified and personnel are educated and trained to meet the requirements.

competence mapping. Competency mapping is a mapping process that creates a map of individual competency or organizational competency; namely, a competency map. The process may focus on existing competency, required competency or the competency needs of the future, depending on the objectives of the mapping and the expected usage of the map. Competency mapping is a tool for competency management to inform competency related decisions and actions.

competent. Adequately qualified for job or task.

computer based training. Includes the use of personal or network based computer systems and training content that supports e-learning, hands-on, web based courses, usually at the user's own pace. It can be synchronous and asynchronous, as well as on-line, web based, mobile and distance learning.

concept maps. Tools for organizing and representing knowledge. Concept maps include concepts, usually depicted in circles or boxes of some type, and relationships between concepts or propositions, indicated by a connecting line between two concepts.

configuration management. The process of identifying, documenting, upgrading (where necessary), and managing for the lifetime of the nuclear asset the characteristics of an organization's safety case, procedures, operating instructions and all supporting design, maintenance and operational supporting documentation.

core competences/competencies. Fundamental competences/competencies that are needed in order to be able to undertake a specified range of jobs. See *competence/competency*.

corporate memory. The knowledge and understanding embedded in an organization's employees, processes and products or services, together with its traditions and values. Corporate memory can either assist or inhibit the organization's progress. Also termed 'organizational memory'.

critical knowledge. The knowledge that is considered to be significant, vital and essential for a particular task or activity that is linked directly to the management of operational safety requirements and successful commercial business performance. The knowledge established in the context of a particular position that is deemed to be imperative for incumbents of the said position to possess before being allowed to perform associated duties and tasks independently.

cross-functional team. The formation of project or work teams comprising members from different disciplines and/or departments and/or production phases to facilitate knowledge sharing.

database. A collection of information organized in such a way that a computer program can quickly select desired pieces of data. Relational databases are organized by fields, records and tables. A field is a single piece of information, a record is one complete set of fields and a table is a collection of records. Storing content in fields rather than on static pages makes that content appropriate for dynamic delivery.

data mining. A technique for analysing data in databases and making new connections between the data in order to reveal trends and patterns. The process of sorting through large amounts of data and picking out relevant information. Computer based tools to enable the searching and extracting of data or information from existing repositories to extract information and support knowledge reuse or generation.

design basis. The range of conditions and events taken explicitly into account in the design of a facility, according to established criteria, such that the facility can withstand them without exceeding authorized limits by the planned operation of safety systems.

e-learning. An abbreviation of electronic learning, which uses information technology systems to conduct education or training as well as to manage those related activities. Services that are delivered, enabled or mediated by information and computer technologies for the purposes of conducting education or training; and the technology and services that help create, manage and deliver those activities.

expert. Someone widely recognized as a reliable source of technique or skill whose faculty for judging or deciding rightly, justly, or wisely is accorded authority and status by their peers or the public in a specific well distinguished domain.

explicit knowledge. Knowledge that has been articulated or has already been codified in some form such as manuals, procedures, databases or electronic media. Knowledge that can be easily expressed in documents. See also *knowledge*.

implicit knowledge. Knowledge that is held in a person's mind and has not yet been captured or transferred in any form. See *knowledge*.

information. Data that have been organized within a context and translated into a form that has structure and meaning.

Note: information carries with it an implied verified or factual nature that suggests trust and usability. Knowledge is the most philosophical level, where multiple pieces of information are evaluated against relationship, context, experience and background to produce reason, lessons and deductions.

information management. The management of an organization's information resources with the aim of improving the performance of the organization. Information management underpins knowledge management, as knowledge is derived from information. Methods and systems to support information management processes, including records and data management practices.

innovation. The process of creating new knowledge or reusing existing knowledge in a new way to create value.

institutional knowledge. The collective knowledge of all the employees working in an organization or institution.

intellectual capital. A model that can be used to describe organizational competency and consists of human, structural and relational capital. The intellectual material, such as knowledge, information, intellectual property and experience, that can be put to use to create wealth.

intellectual property. Explicit knowledge assets that are protected by law, including patents, trademarks, copyrights and licences.

knowledge. Knowledge is a mix of experiences, values, contextual information and expert insight for acquiring, understanding and interpreting information. Together with attitudes and skills, it forms a capacity for effective actions.

Note: knowledge is a combination of 'knowing facts' about something and 'knowing how' to do something. It refers to a body of facts and principles accumulated by humankind over the course of time. It is distinct from information, as knowledge is information that has a purpose or use. Data lead to information and information leads to knowledge. Knowledge confers a capacity for effective action.

knowledge activities. An organization's knowledge activities are those activities that use knowledge as an important source for accomplishing the tasks. These activities may be a part of an organization's core, support or managerial functions.

knowledge assets. Those parts of an organization's intangible assets that relate specifically to knowledge, such as know-how, best practices, codified explicit knowledge and intellectual property. Knowledge asset refers to an economic view of knowledge resources. Knowledge assets are developed via investments with the expectation that these investments enhance the potential income of the organization.

knowledge base. All the knowledge available to an organization; the fundamental body of knowledge available to an organization, including the knowledge in people's heads, supported by the organization's collections of information and data.

knowledge capture. A process of capturing the knowledge available within an organization and making it available.

knowledge centre. A place where knowledge is gathered and stored and can be accessed and used.

knowledge economy. An economy in which knowledge plays a predominant part in the creation of wealth.

knowledge elicitation interview. Most often conducted in the form of exit interviews, they are a form of tacit knowledge capture from subject matter experts (e.g. employee exit interviews).

knowledge loss. Knowledge loss is the unintended deprivation of valuable knowledge.

knowledge loss risk assessment. Method and process of assessing critical knowledge and resources in an organization and their risk of being lost due to attrition. A process used to determine the potential business impact of the loss of critical knowledge from an organization.

knowledge management. The integrated, systematic approach to identifying, managing and sharing an organization's knowledge, and enabling persons to create new knowledge collectively and thereby help achieve the objectives of that organization.

knowledge management activities. Any activity that promotes knowledge management. It could be a knowledge management practice or a knowledge management project.

knowledge management assessment. Various quantitative or qualitative methods to assess or measure the extent, effectiveness, or quality of knowledge management practices or processes.

knowledge management initiative. The actions initiated by an organization with the aim of addressing a knowledge management issue. It could be a knowledge management practice or a knowledge management project.

knowledge management practices. Practices that may not have the direct aim of supporting knowledge management, but make an important contribution to knowledge management. An example could be learning from past operating experience.

knowledge management projects. Focused knowledge management activities initiated with specific knowledge management objectives. An example could be knowledge loss risk assessment.

knowledge management strategy. A high level plan outlining how an organization intends to implement knowledge management principles and practices in order to achieve organizational objectives. A detailed plan outlining how an organization intends to implement knowledge management principles and practices in order to achieve organizational objectives.

knowledge map. Overview of knowledge assets in an organization. It shows the distribution and correlation of knowledge as well as providing navigation for potential users so that they can find desired knowledge properly. Graphical (diagrammatic) techniques to show associations, linkages, structure, and inter-relationships in concepts or knowledge domains.

Note: knowledge mapping is a process to determine where knowledge assets are in an organization, and how knowledge flows operate within the organization. Evaluating relationships between holders of knowledge will then illustrate the sources, flows, limitations and losses of knowledge that can be expected to occur. See also *concept map.*

knowledge sharing culture. That part of the organizational culture that facilitates and rewards knowledge sharing.

lagging indicators. Typically input oriented and providing information relating to future performance and therefore predictive in nature. Leading indicators are usually more difficult to identify and measure.

leading indicators. Typically output or results oriented relating to historical measures of performance based on past events.

lessons learned. Concise descriptions of knowledge derived from experiences that can be communicated through mechanisms such as storytelling, debriefing or summarizing in databases. (See also *database* and *storytelling*.)

Comment: Lessons learned normally highlight strengths or weaknesses in planning, design and implementation that affect the outcomes, objectives and impact of a project or activity. Such lessons often reflect on ‘what was done right’, ‘what ought to be done differently’ and ‘how to improve the process and product to be more effective in the future’. In the nuclear industry, operating experience (OPEX) feedback is an example of an applied lessons learned programme.

mentoring. A relationship between a more experienced individual and a less experienced individual that exists in a one on one fashion, designed to enhance the mentee's understanding of, and ability to put into practice, knowledge and skills possessed by the mentor. Such relationships are usually established for extended periods of time and typically have general rather than specific objectives. The interactive transfer of knowledge from more experienced to less experienced staff. A dynamic and reciprocal relationship that may take the form of managerial, group or team, or one on one coaching and mentoring.

nuclear knowledge management. Nuclear knowledge management is knowledge management in the nuclear domain.

organizational competency. The ability of an organization to meet its objectives effectively and efficiently through the interaction of people with the appropriate explicit, implicit and tacit knowledge and skills, behaviours and culture, processes, procedures, systems and technology, and organizational structure in its given environment. The combination of human capital, organizational capital and technical capital that it needs to possess.

organizational culture. This encompasses an organization's traditions, values, norms, attitudes and behaviour, in particular as influences on its internal and external interactions.

Note 1: this is the IAEA proposed working definition that is based on Schein's model and is consistent with the IAEA safety standards.

Note 2: in knowledge management, an organization's culture is extremely important — if this is not based on qualities such as trust and openness, it is unlikely to succeed. In the nuclear industry some organizations use organizational culture surveys, which help managers to know the extent to which the organizational climate supports the sharing of knowledge. Knowledge sharing culture is that part of the organizational culture that facilitates and rewards knowledge sharing.

organizational knowledge. This is the knowledge necessary for the operation of the organization's processes and to achieve conformity of products and services.

organizational learning. The ability of an organization to gain knowledge from experience through experimentation, observation, analysis and a

willingness to examine both successes and failures, and to then use that knowledge to do things differently.

Comment: while organizational learning cannot take place without individual learning, individual learning does not necessarily produce organizational learning. Organizational learning occurs when an organization becomes collectively more knowledgeable and skilful in pursuing a set of goals.

organizational memory. The knowledge and understanding embedded in an organization's employees, processes and products or services, together with its traditions and values. Organizational memory can either assist or inhibit the organization's progress. Also termed corporate memory.

organizational silo. A situation in an organization where organizational units become isolated and do not collaborate or share knowledge with others in the same organization.

portal. A special web page that organizes access to all of the on-line resources relating to a topic, similar to providing a 'one stop shop'. A comprehensive access structure for resources that are suitable to support the fundamental activities of knowledge management in a given knowledge domain to communicate, study and do research. Also termed knowledge portal.

post-job briefing. See *after-action review*.

pre-job briefing. A process that involves conducting a structured and facilitated discussion before a task or project is performed to explain what ought to happen. See also *after-action review*.

process oriented knowledge management (POKM). An approach to knowledge management that is designed to provide employees with task related knowledge in the organization's business processes. At the heart of the process oriented knowledge management strategy is a workflow management subsystem that enables it to capture knowledge in context as it is created and present knowledge to the user at the right stage of the process. POKM is an approach to the management of knowledge management processes by embedding them in the integrated management system and utilizing technologies, processes and people that ensure the most effective creation, dissemination and utilization of knowledge, and systemic and rigorous decision making in an organization.

process owner. An individual who possesses the knowledge and all the information regarding the process flow is responsible for process outcomes and effectiveness and has appropriate authority for implementation, maintenance and improvement of the process.

storytelling. The practice of relating personal recollections, impressions, perspectives, observations and interpretations, typically with the aim of conveying a particular series of events that collectively convey a message that is of use to the listeners.

Comment: civilization has spread and advanced through the gathering of people to orally share perspectives and interpretations of events in their lives and in the lives of others. From such activities, 'stories' have emerged that have been transferred beyond the original gathering in both oral and written forms. This practice is used in business and industry to transmit tacit knowledge orally and to develop learning histories that can then be utilized extensively for a variety of purposes.

subject matter expert. An individual who is in a possession of comprehensive knowledge and experience in a given subject area.

succession planning. Methods and tools to assess the requirements for specific skills. A methodology for identifying and developing employees to ensure that key organizational positions can be filled with qualified internal candidates, in advance of actual need, and to assist in managing diversity and workforce planning.

tacit knowledge. Tacit knowledge is knowledge that is wholly embodied in the individual, is rooted in practice, experience, intuition and individual skills and is difficult or even impossible to recall, articulate and thus to transfer.

Note: tacit knowledge is the knowledge held in the mind of individuals and is often unspoken and difficult to articulate, share or transfer. However, it may be partially transferred from one individual to another individual using different tools and methods. The consensus amongst knowledge management professionals is that most of the knowledge in any organization is tacit.

taxonomy. A hierarchical structure in which a body of information or knowledge is categorized, allowing an understanding of how that body of knowledge can be broken down into parts, and how its various parts relate to each

other. Taxonomies are used to organize information in systems, thereby helping users to find it.

undocumented knowledge. Knowledge in an organization that has not been documented in such a way that it is accessible to those who may need it.

wiki. The collaborative creation, modification or deletion of knowledge content through an on-line medium.

workforce planning. The systematic identification and analysis of what an organization (and a country) is going to need in terms of the size, type and quality of workforce to achieve its objectives. It determines what mix of experience and competencies are expected to be needed and identifies the steps that ought to be taken to get the right number of the right people in the right place at the right time.

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Consultants Meetings

Vienna, Austria: 18–29 November 2013, 4–8 April 2016, 20–24 February 2017, 1–13 October 2017, 14–18 May 2018

Technical Meetings

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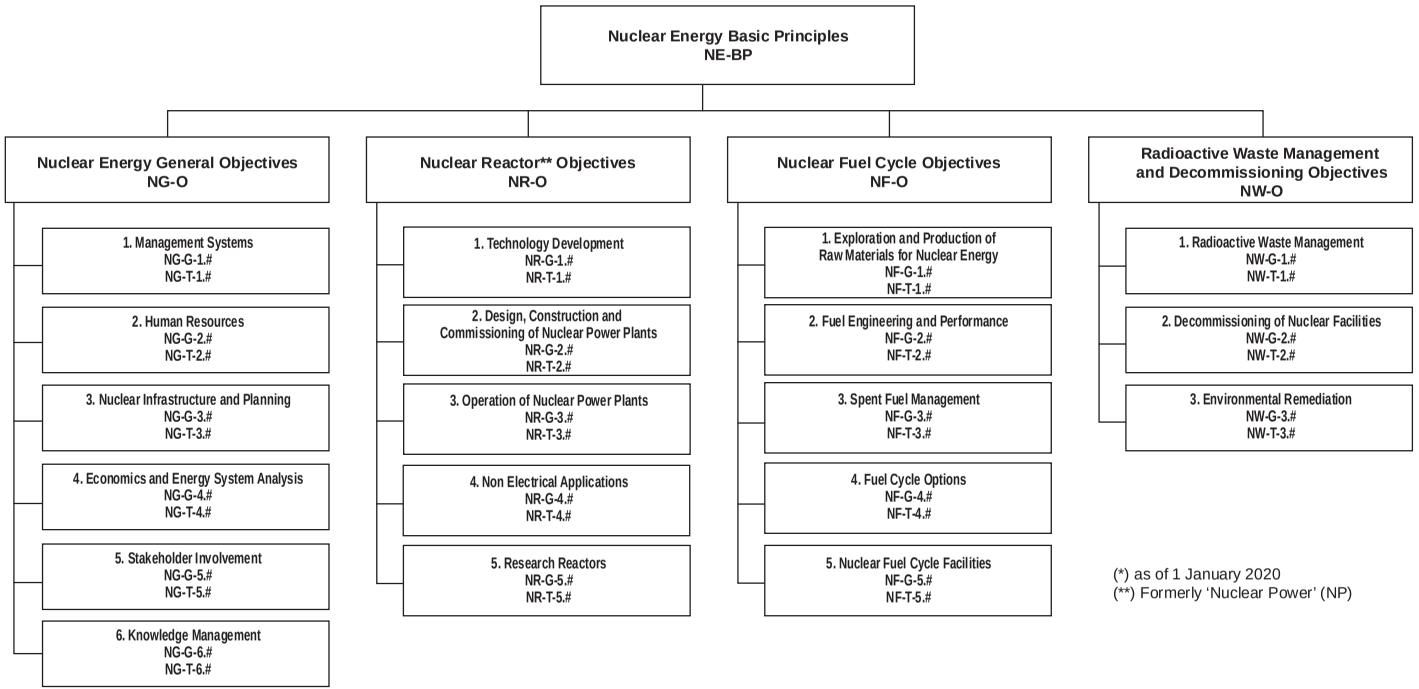

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