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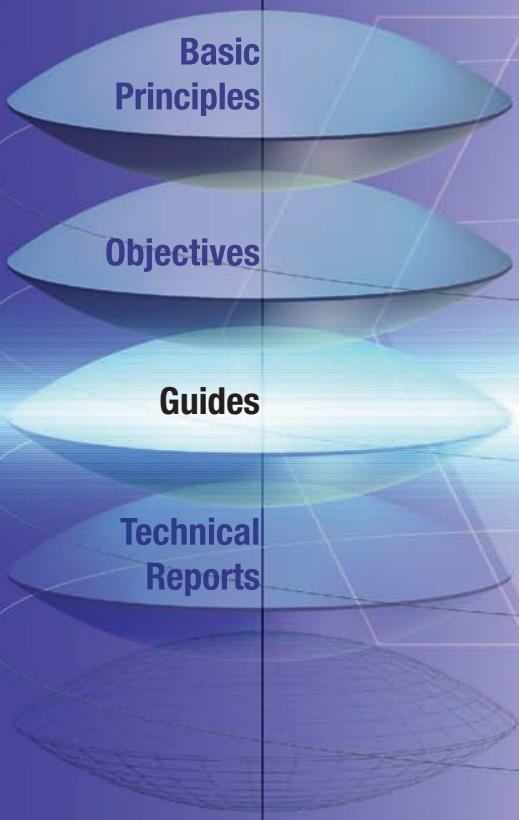

Managing Human Resources in the Field of Nuclear Energy

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MANAGING HUMAN RESOURCES IN THE FIELD OF NUCLEAR ENERGY

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

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MANAGING HUMAN RESOURCES IN THE FIELD OF NUCLEAR ENERGY

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FOREWORD

The nuclear field, comprising industry, government authorities, regulators, R&D organizations and educational institutions, relies heavily on a specialized, highly trained and motivated workforce for its sustainability. An ageing workforce, declining student enrolment and the resultant risk of losing accumulated nuclear knowledge and experience for expanding or newly established nuclear programmes are all serious challenges that influence the management of human resources (HR) in the nuclear field.

The management of human resources requires particular attention in the field of nuclear energy, both because of the high standards of performance expected in this field and the considerable time needed to develop such specialists. The peaceful uses of nuclear energy were primarily developed during the second half of the twentieth century. The nuclear field is now at a mature stage of development, with those who were pioneers in the field having retired and their responsibilities handed over to subsequent generations. For those aspects of the nuclear field related to nuclear power, a great deal of effort has been devoted to managing and continuing to improve the safety and operational performance of existing facilities. However, indications are that the next decades may see considerable expansion to meet increasing energy needs, while responding to concerns about the environment, including global warming. Thus, in the nuclear field, those Member States with existing nuclear power programmes may be forced to replace a large part of their current workforce, while also attracting, recruiting and preparing a fresh workforce for the new facilities being planned. At the same time, those who will be initiating nuclear power programmes, or other peaceful applications, will be developing HR for their programmes. In the past, the development of human resources in the nuclear field has depended on considerable support from organizations in the country of origin of the technology. This is expected to continue to be the case in the future. However, there is also expected to be greater worldwide mobility of nuclear personnel in the future, making human resources management more demanding, particularly in continuing to ensure that organizations in the nuclear field are attractive employers compared with other related choices.

The guidance provided in this publication is intended to comprehensively address aspects of managing human resources in the nuclear field; these include ensuring that individuals have the competence needed to perform their assigned tasks, organizing work effectively, anticipating human resources needs, and monitoring and continually improving performance. This publication is applicable to the entire life cycle of nuclear facilities.

This guide is intended for use by decision makers and senior managers responsible for the reliable supply of a competent workforce for the nuclear field, and also by line managers of nuclear facilities, who are responsible for the training, qualification and performance of their personnel, as well as for HR specialists in the nuclear field.

The IAEA officers responsible for this publication were T. Mazour and A. Kazennov of the Division of Nuclear Power.

EDITORIAL NOTE

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1. INTRODUCTION

1.1. BACKGROUND

The extent to which nuclear energy can achieve its potential of contributing to peace, health and prosperity throughout the world ultimately depends on the availability of suitable human resources (HR). The nuclear industry places very rigorous demands on such resources for reasons such as:

- The complexity of the technology necessitates its introduction and application by highly educated and trained staff;
- The potential safety and proliferation consequences of misusing the technology demand high standards of performance;
- The defence in depth strategy for nuclear facilities necessitates a rigorous, independent checking approach, which can be challenging when maintaining individual vigilance and motivation;
- Only personnel with ethics and values consistent with the above requirements are suitable for this industry;
- The 'need to know' aspects of safeguarding nuclear weapons technology and materials can be a barrier to effective communication with stakeholders, both internal and external to the industry;
- A high intolerance of factors increasing the frequency or consequences of human errors is important; however, this same high intolerance of human error can be a barrier to individuals reporting events or identifying ways for continual improvement;
- Assessing the performance of nuclear industry personnel is necessary; however, if not properly implemented, assessment can be a source of stress and career uncertainty for personnel;
- The need for a prompt response in the event of an incident or accident and for comprehensive monitoring of nuclear facilities 24 hours a day, 7 days a week, make shift work and on-call assignments a necessity.

The above demands make it uniquely important for the nuclear industry to attract and retain suitable personnel, both to staff existing facilities and to support expected expansion. These demands also indicate the unique importance in the nuclear field of people knowing what is expected of them, and feeling responsibility for the quality of their work. In some Member States, this is referred to as nuclear professionalism.

There is currently no authoritative determination of the number of people who are involved worldwide in the: design, manufacturing, construction, commissioning, operation and decommissioning of nuclear facilities; engineering and technical support; training and education; nuclear regulatory bodies and other government authorities; R&D; radioactive waste management; radiation protection; outage support; fuel supply; and supplying other services for the nuclear industry. However, based upon published national surveys, it is clear that the worldwide total is well over a million people. If the forecasted expansion in nuclear power occurs, the number of personnel will need to expand significantly. Many of those currently working in the nuclear industry are retiring and attrition of competent personnel is a real risk for the nuclear industry. Thus, the nuclear industry will have to recruit a large number of suitably educated and qualified individuals, and to provide them with the training and experience needed to qualify them for their demanding assignments. This situation is even more challenging because, in many Member States, careers in engineering, in general, and in the nuclear industry, specifically, are not as attractive as in the information technology or business fields for the most talented young people.

In this guide, the management of human resources has four interrelated objectives:

— Ensuring the competence of nuclear industry personnel is developed and maintained (Section 3);
— Effectively organizing work activities (Section 4);
— Anticipating HR needs (Section 5);
— Monitoring and continually improving performance (Section 6).

These objectives are interrelated; therefore, achievement of each is dependent upon the others. Thus, there is no one best order in which to discuss their achievement. However, in this publication, the order chosen provides a logical sequence. Section 3 highlights those aspects related to the competencies needed by individuals to perform their assigned tasks. Section 4 discusses the organization of work to effectively carry out the organization's processes and to achieve its objectives. Section 5 focuses on anticipating HR needs as the organization's goals and objectives change, and as people change roles or leave and need to be replaced. Finally, Section 6 presents means to monitor and continually improve the performance of individuals, the organization and its processes during its full life cycle.

1.2. PURPOSE

The purpose of this publication is to provide guidance for addressing the management of human resources in the field of nuclear energy to ensure its safe, efficient, economic and reliable use.

This guide should be used for:

— Ensuring that personnel have the necessary competence for their jobs;
— Organizing and enabling work activities;
— Anticipating human resource needs;
— Monitoring and continually improving performance.

1.3. SCOPE

This publication is applicable, in a graded manner, to:

— Nuclear facilities, including nuclear power plants, and nuclear fuel cycle and waste management facilities;
— Activities using sources of ionizing radiation;
— Radioactive waste management;
— The transport of radioactive material;
— Radiation protection activities;
— Any other activities or circumstances in which people may be exposed to ionizing radiation;
— The regulation of such facilities and activities;
— Other activities affecting nuclear facilities and entities involved in the nuclear industry sector (such as R&D organizations, suppliers or contractors to nuclear facilities, technical support organizations and government ministries).

This guide is applicable to the entire life cycle of nuclear facilities including siting, designing, constructing, commissioning, operating, modernizing and decommissioning. It is also applicable for governments and organizations considering the introduction of nuclear programmes.

All IAEA Member States have textbooks and other materials related to the management of human resources. Member States also offer graduate and undergraduate university programmes to develop HR professionals. This publication is intended to supplement these programmes and materials by

providing guidance on HR issues that are either unique to, or are particularly important to, the nuclear industry.

This guide is supported by other reports in the IAEA Nuclear Energy Series and other IAEA publications that provide additional details regarding good practice and experience in the nuclear industry. The bibliography provides a list of related IAEA publications.

1.4. USERS

It is anticipated that the main users of this guide will be decision makers and senior managers responsible for the reliable supply of a competent workforce for the organizations and activities identified in Section 1.3, and those responsible for ensuring that the performance of personnel meets the high standards required by the nuclear industry. Guidance provided in this publication applies to both established nuclear programmes and Member States that are considering the introduction of nuclear programmes. Appendix I provides further information regarding HR considerations that are particularly important when initiating new nuclear programmes.

This guide is aimed at decision makers, senior managers and staff, in a range of organizations, who are responsible for the competence of personnel and their performance (Fig. 1).

FIG. 1. Organizations in the nuclear field requiring human resources.

2. AN INTEGRATED MANAGEMENT SYSTEM AS A FOUNDATION

2.1. IAEA GUIDANCE REGARDING AN INTEGRATED MANAGEMENT SYSTEM

The IAEA Safety Standards Series publication on the application of a management system for facilities and activities [1] indicates that an integrated management system (IMS) should be used to provide a comprehensive framework for the arrangements and processes necessary to address all the goals of nuclear industry organizations, including safety, health, environmental, security, quality and economic elements, and other considerations such as social responsibility. Furthermore, this publication indicates that the practices and results achieved by nuclear industry organizations, the organizational culture and the management processes are strongly interrelated. People in an organization and its culture should, therefore, be as much a part of the IMS as the facility equipment. The organization's policies and procedures should describe an integrated approach in which its employees and equipment carry out the processes that achieve its mission.

Reference [1] indicates that the top level structure of a management system should include the:

— Vision, mission and goals of the organization;
— Policy statements of the organization;
— Organizational structure;
— Levels of authority, responsibilities and accountabilities of senior management and organizational units;
— Structure of the management system documentation;
— Overview of the organization's processes;
— Responsibilities of the owners of the processes;
— Arrangements for measuring and assessing the effectiveness of the IMS.

Guidance regarding how to address the above topics is provided by the IAEA through a combination of IAEA Safety Standards and IAEA Nuclear Energy Series publications. Accordingly, these topics are addressed in this guide only as they relate to the management of human resources. The relationship between the IMS and the contents of this publication are shown in Fig. 2 and are further elaborated in Section 2.2.

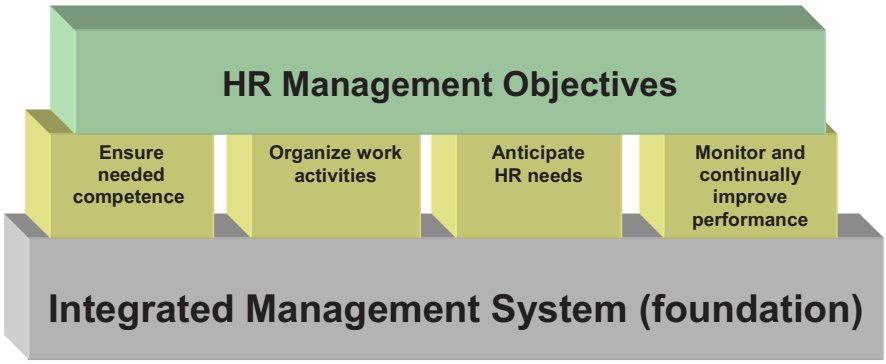

FIG. 2. Human resources management objectives addressed in this guide.

2.2. HUMAN RESOURCES RELATED ASPECTS OF AN INTEGRATED MANAGEMENT SYSTEM

The following elements of an IMS are specifically related to HR in the nuclear industry and are addressed in this guide.

The organization should ensure that all of its personnel have the competencies needed to perform their assigned tasks by:

- Recruiting individuals who have education and experience suited to their position;
- Selecting individuals whose attitudes and values are appropriate for working in the nuclear industry, and who have the best qualifications for the identified positions;
- Providing initial training and qualification programmes that are systematically developed and implemented, based on job responsibilities;
- Authorizing personnel in the performance of tasks that ensure the safe and reliable operation of a nuclear facility, to work unsupervised, if appropriate, but based upon objective evidence that they have achieved the standards required for their position;
- Providing continuing training and development programmes that ensure personnel maintain competencies in their current positions, as well as preparing them to take on emerging tasks or advancement;
- Managing training programmes such that the facilities and human resources needed to sustain the training programmes are available, and that training provides value to the organization.

Guidance on how to achieve these elements is provided in Section 3.

The organization should organize work activities to achieve its objectives through means such as:

- Aligning HR policies and programmes with the organization's overall strategic goals and objectives;
- Clearly defining job responsibilities and authorities, and appropriately designing the organization;
- Providing supervisors with tools to aid them in assigning tasks only to suitably trained and qualified personnel;
- Providing employee benefits to retain good performers;
- Measuring employee satisfaction, motivation and engagement; recognizing and rewarding performance that helps work groups achieve their goals; and correcting behaviour that is counterproductive to the organization's goals and policies;
- Ensuring effective teamwork, both internal to the organization and with suppliers and contractors;
- Providing leadership by the managers at all levels in setting and communicating organizational values and reinforcing professional ethics.

Guidance on how to achieve these elements is provided in Section 4.

The organization should anticipate its future staffing, competence and performance needs by:

- Effective workforce planning, including anticipating needs for new employees, succession planning, and assessing demographic and economic conditions;
- Developing and maintaining relationships with educational and professional organizations;
- Identifying and planning for needed changes in the organization's processes, tools and equipment, and related staffing implications;
- Monitoring situations external to the organization for conditions that may impact on its HR.

Guidance on how to achieve these elements is provided in Section 5.

The organization should continually strive to improve performance by:

- Identifying desired performance;
- Establishing effective means to monitor performance;
- Ensuring that reward and recognition systems support the achievement of the organization's performance objectives;
- Identifying performance gaps and their underlying causes;

— Identifying and implementing appropriate solutions;
— Establishing a learning culture in the organization;
— Capturing and transferring critical knowledge needed to achieve the organization's mission.

The objectives in the paragraph above all relate to 'performance improvement'. The term performance improvement, as used in this publication, is the systematic process of determining desired performance, discovering and analysing performance gaps, designing and developing effective interventions, implementing these interventions, and continually evaluating the results. Performance improvement is undertaken, as discussed in Section 6, at three levels: the organizational level, the process level and the job level. Guidance on how to achieve these elements is provided in Section 6.

The guidance provided in this publication expands upon the IMS approach, particularly the systematic, process based approach identified in Ref. [1].

3. ENSURING THAT PERSONNEL HAVE THE NEEDED COMPETENCE

3.1. COMPETENCE OF PERSONNEL

Competencies are knowledge, skills and attitudes in a particular field, which, when acquired, allow a person to perform a job or task to identified standards. However, competencies alone are not sufficient; people should be able to use them. Competence is the ability to put the competencies (i.e. skills, knowledge and attitudes) into practice in order to perform activities or a job in an effective and efficient manner within an occupation or position to identified standards. Competence is built and maintained through a combination of education, training and experience, and continuing and refresher training in addition to initial training and performance improvement initiatives. As shown in Fig. 1, expectations regarding individual competencies and behaviours in a nuclear organization should be defined as part of the IMS.

All three domains of competence — knowledge, performance and attitude — are important. To acquire various types of knowledge — explicit or tacit — appropriate knowledge management, and education and training should be employed. Appropriate attitudes of nuclear facility personnel have

to be ensured. Due attention should be paid to the fact that the required attitudes cannot be achieved only through education and training. Attitudes also depend on individual characteristics and organizational culture. The behaviour of nuclear facility managers and their ability to be every day role models for their personnel are crucial factors.

The role of experience in building competence is very important. For nuclear facility positions that are important for safe and reliable operation, the work experience required should be clearly identified.

The most effective way to learn a new skill or behaviour is to apply knowledge in the workplace and practise skills in real life situations or, where safety related constraints exist, in a simulator. Training activities using simulators or training in the workshop and laboratories, or structured in-plant on the job training, are effective methods of gaining job experience. To develop appropriate behaviour in abnormal and accident conditions, and for emergency preparedness, full scope replica simulator training or emergency drills can provide opportunities to gain 'hands-on' practice in a close-to-real work environment.

The qualification and authorization of personnel are important elements when ensuring personnel competence.

The qualification of personnel has to be recognized through formal assessment of competence, including demonstration and assessment of its identified elements. Qualification requirements should be clearly stated in job descriptions.

For particular positions — e.g. jobs having a direct bearing on safety — formal authorization to discharge duties should be required. However, the methods and practices for authorization vary between Member States. In some Member States, the regulatory body grants the authorization for positions such as nuclear facility operators; in other Member States, the operating organization has the responsibility for granting authorization for various nuclear facility personnel including some management positions.

Recruiting and selecting suitable candidates are the first important steps for ensuring competence. Recruitment and selection are addressed in Section 3.3, after first introducing the concept of a systematic approach to training (SAT) in Section 3.2. This sequence provides the opportunity to demonstrate how SAT should be used to develop suitable selection criteria.

Examples of competencies required for various job classifications and activities are provided in the references (for nuclear power plant personnel in Refs [2, 3]; for nuclear facility decommissioning managers in Ref. [4]; for nuclear power plant managers in Ref. [5]; for instructors in Ref. [6]; for contractors in Ref. [7]; for regulatory body staff in Ref. [8]; and for research reactor personnel in Ref. [9]).

3.2. PROVIDING INITIAL TRAINING AND QUALIFICATION PROGRAMMES

The training and qualification of personnel in a nuclear industry operating organization should be viewed as a process within the organization's overall management system and should be fully integrated into this system.

SAT should be used for attaining and maintaining the competencies of nuclear facility personnel (see also Ref. [2]). SAT is entirely compatible with an IMS as it is also a process based, result oriented, systematic approach, as shown in Fig. 3.

Through the analysis and design phases, training is focused on certain necessary job specific competencies. Evaluating the training programme's performance and continual improvements help maintain the training programmes up to date, and significantly contribute to the quality of training.

The benefits of SAT based training and qualification processes are numerous for both the organization and its personnel. The most important of these benefits is ensuring both the quality and relevance of training. However, for a nuclear industry organization to achieve these benefits from SAT, line managers must believe that training programmes for their personnel 'belong to' or are 'owned by' them. Specific actions that ensure such ownership are addressed in Section 3.7.

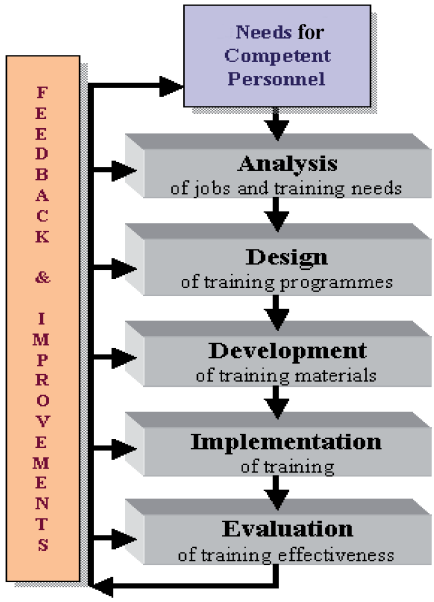

FIG. 3. Overview of the SAT process.

The implementation of SAT based training requires significant resources. Accordingly, graded implementation of SAT may be preferable. A graded approach includes the use of different analysis phase techniques or selecting particular training methods, taking into account the following factors:

— Mission of a facility;
— Life cycle stage of a facility;
— Particular characteristics of a facility;
— Type of position (e.g. maintenance employee, operator or manager);
— Importance of the job relative to safe and reliable performance;
— Magnitude of any hazards involved.

SAT based training has been established as a guideline for nuclear facility training programmes through a variety of mechanisms. In some Member States, SAT based training is a regulatory requirement, while in others it is established through industry initiatives or by an operating organization's policies.

3.2.1. SAT analysis phase

For all job classifications that have a potential impact on the safe and reliable operation of nuclear facilities and activities, the training needs associated with both technical competence and soft skills should be considered and analysed as part of the SAT process. Examples of information and events that should trigger training needs analysis include:

— New or modified nuclear facility equipment;
— New or revised procedures;
— New regulatory requirements;
— Feedback from job incumbents, supervisors, trainees or instructors;
— Training programme evaluations, including self-assessments;
— Nuclear facility or industry events;
— Root cause analysis and corrective action reports;
— Identified weaknesses in training processes;
— Performance deficiencies;
— New job or training standards;
— Competence assessment (examination) failures;
— Anticipated changes needed to respond to environmental/external events.

Another important activity of the SAT analysis phase is job analysis. Job analysis is a method used to obtain a detailed listing of the duties and tasks of a

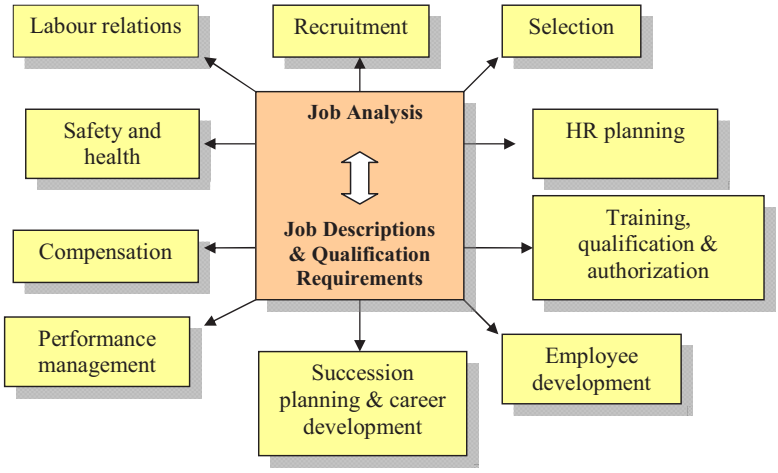

FIG. 4. Job analysis applications.

specific job. The results of job analysis are an important input to the SAT design phase. As shown in Fig. 4, job analysis results are also important for other HR related purposes.

3.2.2. SAT design and development phases

The results from the SAT analysis phase provide the basis for developing training objectives that are clear, measurable and based on job requirements. Training objectives that are appropriately developed provide the basis for designing training programmes, developing training materials and performing post-training assessments of competencies.

Training settings, methods and training tools, suitable for achieving training objectives, should be identified within the SAT design phase. Training tools that are particularly important in the nuclear industry include:

— Simulators, including full-scope simulators, part-task simulators, analytical or functional simulators, and basic principle simulators (the latter includes simulators for educational purposes);
— Equipment in workshops and laboratories;
— Mock-ups;
— Computer based and web based training systems; tools for e-learning;
— Video and audio training aids;
— Data and knowledge bases, information technology and communication aids.

Training tools should be supported by suitable training materials (such as lesson plans, simulator exercise guides and workshop training guides), which are developed during the SAT development phase.

To effectively build the competence of personnel, the following methods should be used in a balanced manner:

— Education;
— Participation in various projects and external work groups;
— Performance based formal training, including on the job training;
— Informal training methods, performance feedback and coaching.

For the transfer of tacit knowledge, efficient methods are on the job training, networking personnel using mechanisms such as communities of practice, temporary work assignments, rotation, performance feedback and coaching.

Particularly important activities within the SAT development phase are the training of instructors and validating training materials by trial usage to ensure the required quality of training delivery.

3.2.3. SAT implementation phase

This is the phase when training is conducted. Only relevant training is provided, because SAT based training is based on training objectives that are derived from an analysis of job needs. The SAT implementation phase also includes an assessment of whether personnel have achieved the standards identified in the training objectives (the standards and associated assessment methods are determined during the design phase). Thus, the implementation of SAT based training is both efficient (providing only needed training) and serves as a basis for measuring and increasing the effectiveness of the training (by assessing that essential competencies are developed within the implementation phase).

The assessment of competencies, for the purpose of qualification and authorization of personnel to work without direct supervision, is discussed in Section 3.4.

3.2.4. SAT evaluation phase

The SAT evaluation phase focuses on the evaluation of training programmes, including a determination of their effectiveness (rather than assessment of competencies of individuals, which, as already indicated, is part of the SAT implementation phase). This evaluation is conducted to both

increase training effectiveness and improve performance. Performance improvement has received increasing emphasis for nuclear facilities. One of the results of this emphasis is to ensure that SAT supports improving performance as well as achieving needed competence.

Performance improvement and SAT have common origins. In particular, the evaluation phase of SAT and the associated feedback loop have much the same focus and objectives as the performance improvement model shown in Section 6. Evaluation of training should be conducted to improve training programmes and also to improve performance. Evaluation should be continually and systematically undertaken in order to determine the effectiveness of training programmes in producing competent employees who can achieve the organization's mission, goals and objectives.

Four levels of evaluation are often used to determine the impact of training (see also Ref. [10]):

— Level 1: Participants' reactions to the training;
— Level 2: Participants' achievement of training objectives;
— Level 3: Transfer of competencies acquired through training to job performance or behaviour;
— Level 4: Impact of training on organizational performance.

Four activities should be performed when evaluating training:

— Monitoring training system performance indicators;
— Analysing data resulting from monitoring;
— Undertaking changes for identified deficiencies or development needs;
— Evaluating effectiveness of improvement actions taken.

For the purpose of monitoring, nuclear facility managers should establish training performance indicators.

Evaluation of training should be viewed as an integral part of the evaluation and improvement of a nuclear facility's performance. Changes derived from evaluation of training may apply to the improvement in training or to other management initiatives. Figure 5 illustrates this approach.

Managers of nuclear facilities should embrace their roles in evaluating training to improve its effectiveness and to improve performance, in the same way as they embrace performance improvement. They are responsible for the behaviour of their employees and for the consequences of that behaviour. Following training, managers should observe the performance of their recently trained employees, provide timely, behaviour specific feedback to those employees, evaluate the impact on organizational performance and provide

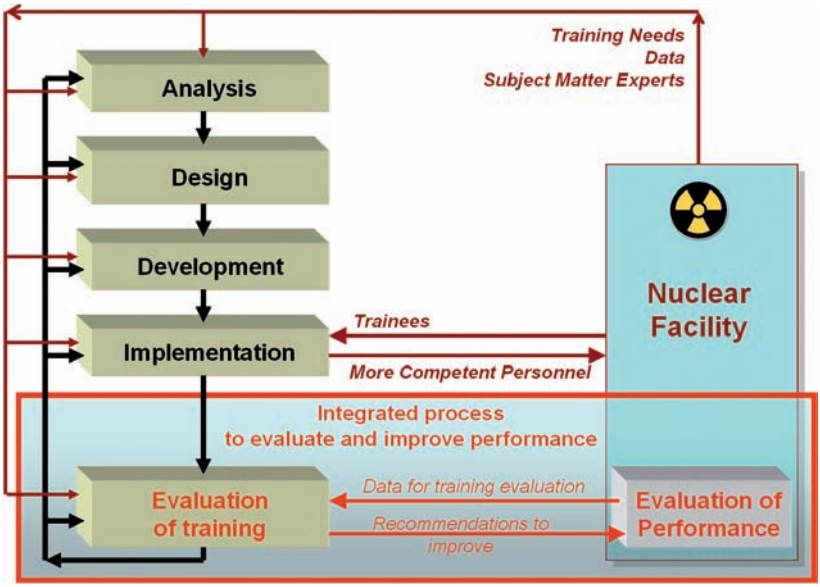

FIG. 5. Integration of training and nuclear facility performance improvement.

feedback to the trainers so that they can improve the quality of the training. Not only the employees of the nuclear facility should be subject to performance improvement initiatives. The performance of contractors should also be monitored and assessed, and any necessary action taken to bring about improvement.

The most effective approach to implementing the evaluation phase of SAT and performance improvement is to jointly use the two processes, and to look for comprehensive means to bridge performance gaps. It is rarely the case that a single solution for a performance gap is appropriate. An analysis of the nuclear industries of some Member States identified that training is one of the causes of approximately 20% of the events reviewed for a period of several years. Training solutions should be integrated with other identified solutions (such as improved procedures or other documentation, better verbal communication and more effective supervision) to achieve the desired changes in performance or behaviour.

3.3. RECRUITING AND SELECTING INDIVIDUALS

It is important to recruit and select individuals who have education, experience and values suitable for positions in the nuclear field. For SAT based

training programmes, particular consideration is given to determining, during the analysis and design phases, which education and experience should be a prerequisite for a particular job (based upon competencies needed for job performance). These prerequisites are the basis for assumptions that certain competencies for particular jobs will be developed through education and experience, and need not necessarily be included in training programmes. Fulfilling formal education, experience, training and other requirements to be authorized for certain nuclear facility positions, especially safety related positions, are mandatory in most Member States.

Each Member State with nuclear facilities and nuclear related activities sets its own requirements related to the education, training and experience of the personnel who operate and maintain such facilities and equipment. While these requirements are consistent with IAEA Safety Standards, there is a good deal of variability. For example, in some Member States, to be eligible to be a reactor operator of a nuclear power plant, an individual is required to have a university degree in science or engineering, while in other Member States only a high school diploma is required. However, the competencies required for a reactor operator in different Member States, having the same or similar nuclear technologies, are generally the same. In the case of a reactor operator candidate with a high school diploma, the operating organization's training programme will need to include training on knowledge related to engineering or technical topics that a candidate with an engineering or science degree will already have. In both cases, the competencies needed to safely and effectively operate the facility equipment are the same. The only difference is whether the competencies are achieved through job specific training, or through prerequisite education or training courses provided before the individual is recruited and selected for the position. Education programmes in support of the overall nuclear industry, including the benefits of partnerships between nuclear industry organizations and educational institutions, are discussed further in Section 5.3.

Effective recruitment and selection processes are particularly important for nuclear facilities and nuclear related activities due to the long period of time that is needed to train and qualify personnel. For some positions, in addition to degree requirements in engineering or science, formal training programmes can have a duration of up to four years. Furthermore, the consequences of making a 'bad' selection are significant in terms of both performance and costs. Thus, the effective use of selection tools is important.

The long training periods needed for nuclear facility personnel also cause many organizations to favour promotion from within over recruiting externally. For example, some organizations have used a policy of developing technicians working within the organization to prepare them for certain junior engineer

positions. Vacancies for foremen and supervisors are often filled internally; such a policy makes it particularly important to select individuals for these positions, based upon essential supervisory competencies in areas such as communication, coaching, team building and motivating, and to provide training and development opportunities regarding these soft skills for prospective supervisors.

New nuclear facilities have often adopted a strategy with a mix of experienced personnel from existing facilities in key positions, with entry level positions staffed with young people who are recent graduates from universities and technical schools. This approach provides an effective means of transferring the operating organization's existing culture and work management methods to the new plant.

It is also important to recruit and select individuals who have attitudes and values appropriate for working in the nuclear industry. Selection tests have been designed to assess the extent to which candidates have ethics and values consistent with those of the organization, such as honesty and respect for others. Some nuclear organizations use such selection tests. Another approach used in the nuclear community is a probationary period of some months, before the individual becomes a 'permanent' employee. During this time, the individual's behaviour is observed to ensure that it is consistent with the organization's values and ethics.

In some Member States, selection tests include screening for use of illegal drugs or abuse of alcohol or other legal drugs.

Differences in national laws and culture regarding employment and individual privacy dictate which selection tests and methods are suitable for a particular organization. In some Member States, selection tests are required by law to be based only on job requirements. SAT is particularly beneficial in these cases, as the analysis phase of SAT provides a clear link between specific job requirements and needed competencies. If selection tests are based on these needed competencies, they clearly satisfy such legislation.

The necessity of continually assessing the performance of nuclear industry personnel can be a source of stress and career uncertainty for industry personnel, particularly for some positions, such as control room operators. Selection criteria should consider these factors.

The need for comprehensive monitoring of nuclear facilities 24 hours a day, 7 days a week, and also to provide a prompt response in the event of an incident or accident, make shift work and on-call assignments a necessity. These demands should be considered in the selection of individuals for such positions, as not all individuals are suited to assignments of this nature.

Recruitment and selection in support of the overall nuclear industry are discussed further in Section 5.2.

3.4. QUALIFYING AND AUTHORIZING PERSONNEL TO WORK WITHOUT DIRECT SUPERVISION

Authorization is the granting by a regulatory body or other authority of written permission for an individual to perform specified activities in a nuclear facility, while qualification is a formal determination that an individual possesses the education, training and experience specified for a particular job or function. Both qualification and authorization are used to permit an individual to work without direct supervision, depending on local and national policies. In a nuclear facility, anyone whose job has an impact on safe and reliable operation should be qualified for the assigned position. In most Member States, only a few positions, most commonly control room operator positions, require authorization. Qualification and authorization requirements should be clearly identified in job descriptions.

Relationships between SAT based training and authorization are shown in Fig. 6 (see also Ref. [11]).

A critical component of qualification and authorization processes is the assessment of whether personnel have achieved the standards needed for satisfactory job performance. Through the SAT analysis and design phases, these standards are identified and included as training objectives. Such standards include not only those related to nuclear technology, but also the soft skills needed for satisfactory job performance.

The nuclear industry, justifiably, invests significant resources into conducting assessments of competencies. The following types of tests are used for assessment:

— Written examinations;
— Oral examinations;
— Performance assessments;
— Computer based tests.

Important factors to consider for the assessment of competencies are that the:

— Development of tests should be based on an analysis of the requirements for competencies (e.g. using job and task or job competency analysis data, and training objectives);
— Reliability and validity of tests need to be ensured;
— Results of assessment should be analysed to use them in the qualification and authorization processes, and also in improving training (including the process of assessing personnel competencies).

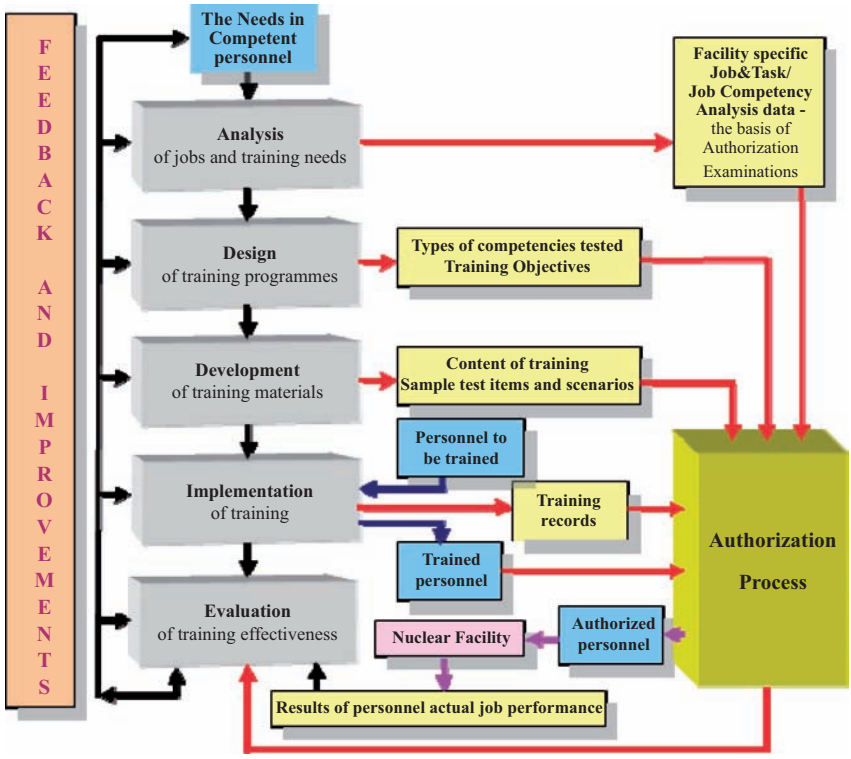

FIG. 6. Relationships between SAT based training and authorization.

3.5. JOB SPECIFIC TRAINING AND QUALIFICATION PROGRAMMES FOR NUCLEAR INDUSTRY PERSONNEL

Nuclear industry organizations generally identify those positions that require completion of formal job training and qualification programmes prior to working on tasks without direct supervision. Examples of such positions include:

— Nuclear facility operators;
— Maintenance personnel;
— Instrumentation and control technicians;
— Facility line managers;
— Nuclear engineers;
— Radiation protection technicians;
— Quality assurance auditors;

— Quality control inspectors;
— Planners (e.g. for maintenance or outages);
— Fuel management engineers;
— Waste management technicians;
— Surveillance and testing engineers;
— Chemistry technicians;
— Electricians;
— Mechanics;
— Full time and part time instructors;
— Emergency planning and preparedness personnel;
— Project managers;
— Commissioning and test engineers;
— Nuclear research facility experimenters;
— Security staff;
— Safety analysis specialists.

Training programmes for these and other nuclear industry personnel should be tailored to the responsibilities and tasks of these positions for the different life cycle phases of a nuclear facility. All aspects of Section 3 in this publication on competence of personnel are relevant for the operational phase. In addition, Appendix I provides HR considerations, including those related to training, for those initiating a nuclear power programme, while Appendix V provides specific training issues for the decommissioning phase of a nuclear facility.

3.6. PROVIDING CONTINUING TRAINING PROGRAMMES

Continuing training programmes are provided to ensure that nuclear industry personnel maintain the competence to perform their assigned tasks, including those that they may perform infrequently, such as responding to emergency or abnormal conditions.

One of the characteristics of SAT based training programmes is that, during the analysis and design phases, specific tasks and competencies are identified that should be included in the continuing training programme for reasons such as:

— The task is performed infrequently on the job, and thus proficiency may not be maintained;
— The task is critical to the organization's mission and/or is difficult to perform, thus periodic practice should be provided.

This information is also useful in identifying knowledge related to these tasks in areas such as fundamentals and regulatory requirements that should be included in continuing training programmes.

Continuing training should also address knowledge regarding facility modifications and changes in procedures and other documentation.

Event analyses, operating experience, corrective action programmes and self-assessments all provide information which can identify performance improvement opportunities as well as the content of both initial and, especially, continuing training. Continuing training is an important tool for performance improvement (see also Section 6).

Another important part of continuing training programmes is to provide operating experience from events that have occurred in the nuclear community or, where relevant, from other industries. An organization should have a system to catalogue events into those that occur at the facility itself or other parts of the organization, those that occur at facilities of a similar design and those that feature in reports from the IAEA, the World Association of Nuclear Operators and other international organizations. The system should ensure that all such events are considered for applicability at the facility. These should be reported, as applicable, to the training department and shared with the rest of the organization.

Some nuclear facilities have adopted just-in-time training, particularly for infrequently performed and/or difficult tasks as either an alternative to, or to supplement, continuing training. As the name implies, just-in-time training is provided just prior to the performance of such tasks.

Continuing training programmes are also important for professional staff as a tool to keep them up to date regarding new techniques in their professions. Such programmes can include not only the opportunity to participate in formal training courses and workshops, but also to be assigned to upgrade or modernization projects.

To make initial and continuing training more efficient, individualization of training and appropriate wavers from training are often used.

3.7. MANAGING TRAINING PROGRAMMES

This section provides overall guidance that managers, particularly senior managers, should consider for sustaining effective training programmes. The bibliography of this publication, particularly the sections on HR development, and training and qualification, provide additional guidance and lessons learned regarding managing nuclear industry training programmes.

Specific factors that enhance line management ownership and control of training include:

— A written training policy document should be endorsed and communicated by senior managers to all nuclear facility staff. Written training procedures should be available and used;
— Line managers need to 'own' the training programmes for their personnel. The maintenance manager must feel responsible for the maintenance training programme, the operations manager for the operations training programme, etc. These managers should be as responsible for making provision for training programmes as they are for providing resources for other needs of their organization;
— First line supervisors should meet with training staff to communicate and discuss training needs, define the scope and content of new training courses and review the appropriateness of existing courses;
— Line managers should review SAT analysis phase data and all training materials during the SAT design and development phases, and provide written comments on the materials. The training group should respond in writing to these comments to the satisfaction of the line manager;
— Line managers should provide on the job training and assessment of employee competence to perform tasks. Supervisors in the line organization should ensure the trainees' completion of the training programme;
— Line managers should be held accountable for the adequacy of training and performance of their personnel. If errors occur due to insufficient competence, the line supervisor should analyse and understand the reasons for these occurrences; suggestions should be made, in conjunction with the training staff, for suitable preventive and corrective actions, and the needed actions implemented;
— Line managers should be able to demonstrate that both initial and continuing training are satisfying the performance requirements for the training programmes and the organization's goals;
— Line managers should support the use of peer reviews and self-assessment processes to ensure their training programmes are robust and are meeting the standards set in the training policy and training procedures;
— Line managers should be responsible for identifying the necessary training requirements to support improving performance. This should be achieved, in particular, through liaison with the training organization and through the relevant training committees;

— An institute of training coordinators who faciliate interractions between the facility departments and training organization should be considered;
— Training organization personnel should meet with line managers, at least annually, in formal meetings with clear objectives to evaluate the training programmes, schedule training for the next year and agree on long term training strategies;
— The plant manager, operations manager or other senior plant supervisors should periodically observe classroom and practical training, and assessments of competencies, particularly simulator or on the job training examinations;
— The training manager should meet regularly with the plant manager to receive advice and direction. Supervisors in the training group should meet regularly with their peers from plant and nuclear support groups, at nuclear facility training review committees, for example, to discuss training programmes;
— Line organization personnel should participate in training development from the analysis phase through to the evaluation phase of the SAT process, and also in the development and revision of training procedures;
— Regulatory body managers should establish mechanisms for independent review of the quality of nuclear industry training programmes, as well as ensuring that regulatory body personnel are suitably trained and qualified for their assignments.

As part of the organization's IMS, both physical resources and human resources essential for sustaining training programmes should be considered. Regarding HR, the individuals who provide instruction are particularly important; those who provide full time classroom training, as well as part time instructors, including those who conduct and assess on the job training, and those who act as mentors/coaches. Technical competence, positive and demonstrated attitudes towards maintaining high standards for the organization's safety culture, instructional capabilities and soft skills are all important. A systematic and reliable process for hiring (including selection), initial training, performance assessment, qualification, continuing training and development of instructors should be established.

Instructors should possess appropriate competence in performance evaluation and improvement.

Feedback to the instructors and external training organizations — on the basis of evaluation of actual performance of the nuclear facility personnel — should be provided in a timely and objective manner.

Rotation of personnel between the nuclear facility and the training organization/department is an effective means of maintaining competence of

the training staff; such rotation also strengthens the relationships between the nuclear facility and the training organization and cultivates an understanding of the significance and complexity of the training in the facility personnel.

National or regional training systems for nuclear industry personnel are often provided. These should be jointly managed with their customers. Training facilities may belong to the nuclear facilities, or be established at the corporate or industry level, or may serve as training centres on a regional or interregional basis. Sharing training infrastructure may be an effective approach. Training centres (either national or regional) will be used more efficiently if considered as centres of excellence for the accumulation of good practices, the study of new technologies, the training of personnel and sharing experiences.

Managers should pay attention to the following considerations:

— SAT based training is a powerful tool for achieving, maintaining and developing personnel competence;
— However, training alone cannot ensure the required competence. Necessary education, work experience, performance evaluation and improvement, and other management initiatives also need to be implemented to achieve the required competence and to promote adequate performance of the personnel.

4. ORGANIZING WORK ACTIVITIES

4.1. ASPECTS OF THE ORGANIZATION OF WORK

This section addresses those HR issues related to how an organization should organize work activities to achieve its objectives, including those aspects related to motivating personnel. Among the aspects addressed in this section are:

— Aligning HR policies and programmes with the organization's overall goals and objectives;
— Clearly defining job/organizational responsibilities and authorities, and appropriately designing the organization;
— Providing suitable employee benefits in order to retain good performers;

— Measuring employee satisfaction, motivation and engagement, and recognizing and rewarding performance that helps work groups achieve their goals;
— Ensuring effective teamwork, both internal to the organization, and with suppliers and contractors;
— Providing leadership at all levels in setting and communicating organizational values and reinforcing professional ethics (this includes building the appropriate organizational culture, mentoring, coaching, acting as role models and conducting observation of work).

The first two items above are related primarily to organizational aspects, while the remaining items deal with enabling aspects regarding motivation of personnel and helping the organization to achieve its objectives.

4.2. ALIGNING WITH THE ORGANIZATION'S OVERALL GOALS AND OBJECTIVES

Aligning HR policies and programmes with the organization's overall goals and objectives is an important aspect of managing human resources.

IAEA Nuclear Energy Series publications in the management systems area, as well as IAEA Safety Standards, are intended to be the primary source of information regarding a nuclear industry organization's structure, policies and procedures. This section addresses those aspects of management systems that are specific to HR. Table 1 provides an example of a management systems strategy related to HR.

Many nuclear industry organizations have been traditionally burdened with paper driven HR processes and administrative tasks. Information networks have a major impact on communicating HR related processes, tasks and data through putting accountability and information in the hands of the decision maker and employee. Computer based tools and computerized documentation and databases may help nuclear operating organizations to make HR related processes more efficient. These include:

— HR policies and procedures;
— Information on benefits;
— Expense reporting and reimbursement;
— Training and qualification/authorization records;
— Training schedules;
— Vacant position postings;
— Integrated performance management;

TABLE 1. ESSENTIAL HUMAN RESOURCES ASPECTS OF THE ORGANIZATION'S OVERALL GOALS

Aspects of management system	HR aspects to be taken into account
Mission	To provide a safe and reliable source of energy to customers at a fair price; (a typical mission for a nuclear power plant).
Goals and objectives	All activities that are important to the organization's mission are carried out in an effective manner consistent with the trust that stakeholders have placed in the organization. These activities are carried out by competent and motivated staff.
Strategy	A process-based approach is used to ensure all aspects are addressed that are needed to provide a safe and reliable source of energy. Processes to manage human resources are established and process owners, competent to fulfil their functions, are identified. HR management is effective and efficient in achieving the organization's goals and objectives. Means to measure and increase the effectiveness of HR management are identified and employed.
Structure	The roles, functions, responsibilities and authorities of all organizational units and personnel are clearly defined, as are interfaces between these units and personnel and external organizations.
People	All employees are appropriately qualified for their jobs, and are engaged in helping the organization to achieve its goals and objectives. Policies to assure competence of contractor personnel are clearly defined and implemented.

— Awards for outstanding performance;
— Emergency contact information;
— Attrition monitoring and planning for its mitigation.

For many nuclear facilities and activities, the above tools are available through internal computerized information systems (such as an Intranet).

One feature that has been particularly useful for nuclear facilities is to provide supervisors with information to support the assignment of work to their personnel. For example, an Intranet application can provide an easy and user friendly means by which supervisors can ensure that the personnel they

assign to tasks have the current qualifications needed to perform those tasks. The system can also identify whether just in time training is needed prior to performing tasks.

4.3. CLEARLY DEFINING JOB RESPONSIBILITIES AND APPROPRIATELY DESIGNING THE ORGANIZATION

The potentially serious consequences of errors make it particularly important to organize work processes and activities with the defence in depth concept that is central to the nuclear industry. Organizational structures that are process-based are conducive to ensuring a defence in depth approach, because a decision can be made for each step in the process to see which mechanism to use for preventing, identifying and correcting errors, and for minimizing their consequences. Another example of applying defence in depth is to ensure that mission critical knowledge is known by more than one person in the organization. In addition, a process based structure can assist in this regard, as job descriptions can be linked to steps in the process, making it clear for each activity in the process which individual (or position) is responsible for the activity.

The potential loss of critical knowledge and skills can be addressed through conducting risk assessments to determine the potential for loss of critical knowledge caused by the loss of experienced personnel; and to enable nuclear organizations to utilize this knowledge to improve the competence of new and existing personnel (see Ref. [12] for additional information).

Task based job descriptions (developed from the job analysis conducted during the analysis phase of SAT based training) should be used for positions such as operators and technicians.

Competence-based job descriptions (developed from job analysis conducted during the analysis phase of SAT based training) should be used for professional jobs such as engineers and managers, as their jobs are not readily presented as a set of precisely defined tasks.

An HR issue of considerable interest to senior managers of nuclear facilities is the size of staff needed for operation, maintenance, technical support and other related services. Similarly, such decision makers will be interested in the extent to which the technology of the facility will permit the use of personnel from the national workforce employed in other industries (for example, craftsmen in the electrical generation industry being used to support nuclear facility outages). It may be feasible to have one maintenance organization for a site, with employees capable of working interchangeably on the units at the site. Many Member States have experienced as much as a 30%

reduction in manpower requirements for new facilities through maintaining an efficient organizational structure.

The quantitative and qualitative characteristics of the staff required for operation and maintenance of a nuclear facility depend heavily on the outsourcing strategy of the organization. Although a facility's operations have traditionally been staffed by operating organization personnel, there have been many cases where maintenance and some technical support functions have been performed through a contract with the vendor that installed the plant systems or components. Whatever the situation, the operating organization can never delegate the responsibility for safety of the nuclear facility. Thus, it has to maintain sufficient competent staff to effectively manage any outsourced activity. Appendix IV provides further information regarding HR considerations for technical support organizations (TSOs) and other contractors.

4.3.1. Centralization of activities

For nuclear industry operating organizations, particularly those with multiple units or multiple sites, a number of functions/processes are typically centralized in the parent/corporate organization. Examples are:

— Budget/finance;
— Chemistry control;
— Communications/public affairs;
— Emergency preparedness;
— Engineering, design modifications;
— Human resources;
— Training (curriculum development, testing);
— Personnel performance management;
— Information technology;
— Licensing;
— Nuclear fuels;
— Outage planning/scheduling (for all units/sites);
— Project management;
— Quality management;
— Radiation protection;
— Industrial safety/health;
— Security/physical protection;
— Procurement (contracting, purchasing, materials management and storing).

The centralization of these functions/processes allows for more efficient application of HR, and assists in standardization of processes across a fleet of nuclear power plants. Consequently, efficiency gains of up to 20% have been realized by some Member States.

4.3.2. Outage management

The management of outages generally requires support from technical specialists not found on the operating organization staff. For example, for nuclear power plants, non-destructive testing is required for life cycle management; such testing requires specialists with specific equipment. Similarly, many nuclear facilities retain a core team of radiation protection technicians and require additional support during major outages such as refuelling. Some nuclear facility operating organizations choose to have in-house operations and maintenance staff qualified in this area while others hire external support companies with experienced technical staff.

In some Member States, an external vendor provides almost all outage activities to the nuclear facility operating organizations; such provision is called a 'turnkey' service. Examples include refuelling activities, non-destructive testing, chemical cleaning, inspection services and maintenance activities. In these circumstances, sufficient technical expertise must be retained by the operating organization to oversee and validate the work performed by contractors.

Nuclear facility operating organizations also need to consider the availability of contractor and consulting services to support operations. Examples include maintenance, engineering and technical support, outage support, radiation protection and administrative support. The range of outsourced services will be determined by: (i) the availability of internal and external skills and resources; (ii) the cost of external services; (iii) the ability of the operating organization to hire and retain personnel internally; (iv) other considerations, including the risk management philosophy of the operating organization.

4.3.3. Standardizing processes

Standardizing processes has some advantages regarding the utilization of HR for reasons such as using previously validated methods and the flexibility to move personnel between different units/plant sites. The following are examples of standardized practices for nuclear facilities:

— Corrective action programmes;

— Engineering design change processes;
— Information technology implementation;
— Particular procedures;
— Organization structures;
— Management systems (including quality management);
— Security;
— Training;
— Personnel performance management;
— Work control/work management.

The approach that an organization takes in standardizing such processes will depend on local, regional and national cultures, as well as the parent/corporate organization's culture, and the standards adopted by the supplier. Some of these areas will also be influenced by requirements established by the regulatory body.

4.3.4. Strategy regarding development and use of procedures

Nuclear energy related facilities and activities generally require a more rigorous use of written procedures than do most other industries. Written procedures are the principal method for communicating management expectations concerning the performance of activities. It is clear that it is neither appropriate nor possible to have a procedure for every activity at a nuclear facility. The degree to which plant procedures are detailed and the level of use (continuous, reference, information) should be determined during the development of the procedure. When a procedure is used at any level, it needs to be followed as described within the procedural guidance expectations of the facility.

Although nuclear facility operating organizations need to require compliance with procedures, some operating organizations, with consent from their regulatory bodies, have less specific technical procedures and rely more heavily on the skills and qualifications of their technical staff. Others have more detailed procedures and require documentation of the execution of each procedure step. In many cases, particularly for new nuclear power programmes, one of the tasks of the supplier is to provide the initial operating and maintenance procedures. Each supplier has its own expectations as to the level of detail of such procedures. In situations where there are units on the same site supplied by different vendors, experience has shown that there can be difficulties for maintenance and operations personnel working on these different units due to variations in strategies used to develop and use procedures.

It is important that there is an appropriate balance and integration between the principal factors that support the activities of nuclear facility personnel, including supervision, training and qualification, work environment and plant procedures. None of these factors alone can ensure adequate performance. Developing any one of these without consideration or knowledge of the others is likely to result in inefficient and/or ineffective performance. The most comprehensive illustration of this is the application of infrequently used procedures for high risk operations. In these cases, some combination of procedure validation, pre-job training and briefing, direct supervision and direct management involvement will be needed to ensure proper task performance and defence in depth.

4.3.5. Operations shift structures

Operations personnel requirements are driven primarily by plant design and regulatory requirements. In many Member States, these requirements result in six shifts of operations personnel. In many Member States, 8 h shifts have been the norm. However, in some Member States, operating organizations have introduced 12 h shifts. Additionally, the nuclear facility operating organization will need to consider the working relationships of other personnel with the rotation patterns of the operations personnel. Other groups may also have rotating shifts, which may or may not be aligned with those of operations personnel. These groups include security, radiation protection and some maintenance functions. In cases where these groups are not working to the same rotation pattern as operations, consideration needs to be given to off-hours support, such as evening and weekend coverage.

4.3.6. Provisions for on-call personnel

The requirements for on-call personnel are normally driven by regulation. Regulations may also define the number of hours a person can work in a given period. Thus, there are conditions when an individual (or group) may not be permitted to be called in for support, and a secondary scheme or group will be needed. Accordingly, an integrated plan should be developed for both technical and emergency response call-outs.

4.3.7. Stakeholder relations

Nuclear facilities in Member States have often had opposition. Local, regional and national entities may support or oppose the construction, operation or early decommissioning of a given facility. To explain the owner/

operator's position to various stakeholder groups, the owner/operator may find it appropriate to employ professional staff to manage these relations. The organizational placement of these types of personnel is dependent upon the nature of the issues at hand. Where the issues are geographically local to the site, organizations usually arrange for a public communications team to be based on-site, and report directly to the site management team. Where the issues are more regional, the team is usually based off-site, within a parent organization. Where the issues are national, the owner/operator may convey its policies through an industry based organization, or employ an outside contractor who specializes in this field (this might be done in addition to, rather than instead of, the operating organization).

4.3.8. Specific human resources issues related to expansion of a nuclear programme

Most nuclear facility operating organizations have adopted a strategy for expansion of a new facility of employing a mix of experienced personnel from existing facilities in key positions, balanced with entry level positions occupied by young people that have recently graduated from universities and technical schools. This approach has proven effective in transferring appropriate work management methods to the new facility. The extent to which existing personnel can be used to occupy key positions in the new facility will have an impact on the recruitment strategy. The redeployment of construction and commissioning personnel as operating and support staff has also proved effective as a strategy applicable for all organizations, whether initiating a new nuclear programme or following an existing one.

Complications occur when delays in construction of new facilities are encountered. Effective means of overcoming moderate delays have been to temporarily reassign key personnel to functions in operating units while waiting for construction to resume.

Another issue occurs when existing facility personnel are attracted by the opportunities to advance their careers in a new technology. If too many people for the new facility are recruited from the operating plant organization, the operating facility's performance may be jeopardized. Some organizations in Member States have encountered this situation, and they report that this issue must be closely managed by senior management as it carefully plans a balanced transition of experienced personnel.

Many nuclear facility operating organizations have found it useful to establish targets for the ratio of experienced/inexperienced personnel for commissioning in each position/function. These targets are generally that around one third of the total number of personnel recruited for a new facility

should have previous experience in a similar position and facility. Other operating organizations have established a target of having experienced persons in all key positions for commissioning (20 to 30 key positions identified). Both experienced and inexperienced personnel should be recruited well in advance of commissioning; enabling them to complete the needed classroom training prior to commissioning, and during commissioning they will be able to receive practical training, as well as contribute to the efficient and effective performance of commissioning tests.

Regarding commissioning of a new nuclear facility, it is important to have a plant referenced, full scope control room simulator in operation at least one year (and preferably earlier) in advance of the facility operating with nuclear material. This simulator not only provides a unique tool for training control room personnel to carry out their assignments, but is also important for such tasks as normal, abnormal and emergency operating procedure development and validation, development and validation of commissioning tests, and training of other plant personnel.

4.3.9. Specific human resources issues related to initiation of a new nuclear programme

Obviously, for an organization that is initiating a new nuclear programme, most of the methods identified in Section 4.3.8 are not available. In these cases, there is a need to rely initially upon suppliers and partnerships with other operating organizations and industry organizations to develop the processes, programmes and work management methods needed for a nuclear facility. More information regarding HR issues related to initiating a new nuclear programme is provided in Appendix I.

4.4. EMPLOYEE BENEFITS

Employee benefits that provide incentives suitable for retaining personnel and for them to contribute to achieving the organization's goals and objectives are an important element of managing human resources.

Large investments are needed to train and develop nuclear facility personnel, as well as a considerable lead time. Increasingly, such personnel have greater mobility to take other positions, whether with similar companies, in other industries or even in other countries. These factors highlight the importance of controlling turnover and monitoring the extent to which personnel are satisfied with their jobs and associated benefits. In the past, the majority of the workforce was expected to remain with the same employer for

their entire career. However, in many Member States, that is not now the case for a variety of reasons. Nuclear facilities such as nuclear power plants, research reactors and waste storage facilities generally have long operating lives, and thus can still offer stable careers for their employees. This can be a positive aspect in recruiting initial and replacement staff.

A nuclear facility should strive to be an organization that people want to be a part of, feel its mission is important, and consider it a good corporate component of the community. A nuclear energy organization needs to be visible and attractive to potential employees who have the values, skills and attitudes suitable for its mission. The long term stability of employment at a nuclear facility should be highlighted as a positive aspect.

In a number of Member States, engineering in general, and nuclear engineering in particular, are not seen as attractive careers currently, particularly compared with information technology and business areas. This, combined with continuing anti-nuclear rhetoric and the demanding aspects of a career in the nuclear industry — as described in the introduction to this publication — makes it a challenge to attract young people to the nuclear energy industry. Continual, safe and reliable operation of nuclear facilities, prospects for interesting and stable jobs, competitive salaries, engagement with young people regarding career opportunities in the nuclear field and changing society's views about nuclear energy may help respond to this challenge. Section 5.3 provides guidance regarding relationships with educational and professional organizations to address this challenge.

It is particularly important that nuclear industry personnel have incentives to exercise conservative decision making and to report precursors to potentially serious events. Questioning attitudes that are the integral part of safety culture should be cultivated. Examples that have been used successfully in this regard are employee suggestion schemes, opportunities to provide complaints anonymously, 'whistleblower' policies and clear policies regarding disciplinary actions for employees who do not comply with the organization's values, ethics and rules. It is important for management to facilitate a culture of trust, such that individual employees will feel secure enough to identify problems that may invoke 'whistleblower' protection, including reporting other employees' apparent lack of fitness for duty.

The following are the types of benefits that nuclear facilities typically offer to their employees:

— Salary (a fair wage, not necessarily excessive);
— Bonuses and/or performance incentive programmes;
— Health and life insurance benefits;
— Benefit programmes for retirees;

— Leave/vacation;
— Employee recognition;
— Educational opportunities and rewards.

The positioning of nuclear facility sites relative to social and cultural infrastructures may have a direct impact on the employees' cost of living and their access to infrastructure such as available housing and public education. Typically, living costs increase significantly in desirable locations. Off-setting this effect somewhat is that recruiting staff is generally easier in a more desirable living area. Some examples of methods that nuclear industry organizations have used to attract and retain suitable personnel include:

— Developing a plant and township infrastructure that is attractive to employees;
— Providing financial incentives related to achieving the organization's goals and objectives;
— Educational support programmes.

Some nuclear operating organizations have found that hiring employees who have ties to the local area can improve retention, particularly at remote locations. To this end, recruiting locally, where possible, even if this means additional training of a lesser-skilled local workforce may be beneficial.

Internal recruitment can have a strong positive influence on retention and motivation; people who join the organization have the expectation that it will continue to provide them with opportunities for professional growth and advancement throughout their career. More specific guidance regarding internal recruitment is provided in Section 3.3.

4.5. MEASURING EMPLOYEE ENGAGEMENT AND REWARDING PERFORMANCE

Almost all activities related to the safe and reliable operation of nuclear facilities involve individuals working as a team, such as part of an operations shift, a maintenance group or a work planning organization. Thus, incentives should focus not only on individual behaviour and competencies, but also on how well individuals work as members of a team and how they contribute to the organization's overall performance. Many nuclear industry organizations give all employees a stake in the performance of the organization, and take other related measures to ensure that individual reward does not damage teamwork and cooperation.

Benchmarking in nuclear industry organizations, as well as in other industries, has indicated that an effective new employee orientation programme contributes to employees being engaged and becoming productive quickly and effectively.

One key incentive for increased employee engagement is regular feedback on job performance.

More information regarding this area can be found in Section 6.

4.6. ENSURING EFFECTIVE TEAMWORK

Ensuring effective teamwork applies both within the organization, and with suppliers and contractors. Sustaining the successful operation of a nuclear facility depends upon the cooperation and high standards of suppliers, contractors and other stakeholders. Mutual respect and understanding among these individuals and organizations is essential.

Operating organizations can delegate authority for carrying out activities, but cannot delegate responsibility for ensuring that work is done properly. Assurance of contractor personnel competence should be addressed starting with the procurement process. Win-win relationships should be established with contractors who are treated fairly and considered as valuable members of the team.

Construction, commissioning and outage management of a nuclear facility provide some of the most difficult aspects of managing contractors and suppliers, due to the large number of people involved and the demanding schedules. Some organizations have been successful in this regard by placing particular emphasis on providing high quality facilities for contractors (of the same standard as are provided for employees) by treating contractors as valuable members of the team (in the same way as employees) and by ensuring that contractor companies share with their employees the incentives that they are provided to achieve the relevant goals.

4.7. MANAGERS PROVIDING LEADERSHIP REGARDING ORGANIZATIONAL VALUES AND ETHICS

Managers at all levels should provide leadership in setting and communicating organizational values and ethics. Because of the high visibility of the nuclear industry with the public and decision makers, clear and open communication on values and expectations is particularly important. Such

open communication helps to build trust among these stakeholders, which is particularly important for the nuclear industry.

As indicated earlier, the IMS, the organization's culture, values and ethics, and the leadership in the organization are closely related. An organization's culture encompasses its beliefs, customs, knowledge and practices. It influences the human behaviour of members of the organization, even though it seldom enters into their conscious thought. People depend on the culture of their organization to give them stability, security, understanding and the ability to respond to a given situation. People fear change because they believe the system will become unstable, their security will be lost, they will not understand the new process and they will not know how to respond to new situations. Changing organizational culture is a major challenge — it is difficult to achieve and does not happen quickly. Change requires leadership, in particular from senior managers in the organization, to convince members of the organization that change is necessary, and then help them visualize what the new culture and organization will be. Change also requires understanding — an understanding of why change is needed and the value of the change — by all involved and all affected by the change.

Research [13] has shown that while globally there are significant differences in regional, national and organizational cultures, there are certain leadership characteristics and actions of senior managers that make positive contributions to organizational performance in all or most cultures. These include:

— Being a leader who respects others, values participation, seeks to develop leadership in others and treats others fairly.
— Living with integrity: not compromising ethics and standards;
— Building a shared identity: trusting, relating to and developing people;
— Ensuring that institutional values and behavioural expectations defined for the organization are clearly communicated and are consistent with its mission regarding the safe and peaceful use of nuclear energy;
— Ensuring that the organization provides suitable incentives and sanctions, such that the values and behaviours of all members of the organization are consistent with the organization's values, mission and objectives;
— Leading by example; continually communicating, through both words and personal example, the high standards of behaviour expected of all members of the organization;
— Building relationships between management and employees, as well as with other stakeholders, based on mutual trust and respect; maintaining an organizational culture that values the capture and transfer of

knowledge critical to the organization's mission and to its continued improvement;
— Continually reinforcing the approach that if capable, well-trained people are placed in a setting with clear expectations, minimal task interference, reinforcing consequences and appropriate feedback, then they will be motivated.

The organizational values and ethics addressed in this section should be considered for the selection, training, qualification, performance assessment and competence development of nuclear facility managers.

Major long term research has identified a set of leader tools that influences the organization. The top six tools of influence are listed below:

— *What leaders pay attention to, measure or control:* Members of organization pay close attention to what is important to their leadership. When leaders ask questions in a given area or about a given subject, members perceive that if the leader is asking, then it must be important;
— *Reactions to critical incidents or crises:* How leaders react to events of consequence or crises is closely observed by members of the organization;
— *Criteria used to allocate scarce resources:* In times of increasing demands of efficiency and effectiveness, where leaders apply resources clearly indicates what is important;
— *Deliberate attempts at role modelling, teaching and coaching:* What leaders do and how they do it — to improve behaviour or develop lower tier leaders;
— *Criteria for reinforcement and discipline:* What is rewarded gets reinforced. What is punished gets extinguished. Some key leaders reward the 'firefighters'— those personnel who frequently avert the crisis situation and save the plant. Not as often recognized is the professional who works hard to keep crises from occurring. This person frequently gets very little visibility because they are so well prepared;
— *Criteria used to select, promote or terminate employees:* Those actions by leaders that indicate which behaviour is most likely to get an individual promoted or in the worst case, their employment terminated.

For more information regarding this area, see also Ref. [14].

5. ANTICIPATING HUMAN RESOURCES NEEDS

5.1. IMPORTANCE OF ANTICIPATING HUMAN RESOURCES NEEDS

The lifetime of a nuclear facility, from its design and construction to the completion of its decommissioning, could be 100 years or more (10 years planning and construction, 60+ years operating life, 30+ years until decommissioning completed, depending upon the approach selected). Thus, three or more generations of personnel may be responsible for the facility. This characteristic, along with the high standards required of nuclear industry personnel, and the long lead times needed to prepare the personnel for their demanding assignments, mean that anticipating HR needs is particularly important for the nuclear industry, including both the costs and benefits associated with these efforts.

5.2. WORKFORCE PLANNING

5.2.1. General considerations in workforce planning

Workforce planning needs to be based on sustaining excellence throughout the life of a nuclear facility, including the capture and transfer of knowledge needed throughout this period. The topic of knowledge management is comprehensively addressed in other IAEA publications, including others in the IAEA Nuclear Energy Series. The bibliography at the end of this guide provides a list of related IAEA publications.

Workforce planning is the process of ensuring that the right people are in the right place and at the right time to accomplish the mission of the organization. Furthermore, workforce planning is a systematic process for identifying and addressing the gaps between the workforce of today and an organization's HR needs of tomorrow. The critical steps of workforce planning are:

— *Assessing the current workforce:* Determining what current workforce resources are and how they will evolve over time through turnover;
— *Analysing the future workforce:* Developing specifications for the kinds, numbers and location of personnel and managers needed to accomplish the organization's mission, goals and objectives. This information will

need to be developed in conjunction with the organization's strategic plans and budgetary requirements;
— *Identifying gaps:* Determining what gaps will exist between current and projected workforce needs;
— *Developing strategies to rectify gaps:* These strategies include identifying potential sources of needed personnel, recruiting, training/retraining, restructuring organizations, contracting plans (for labour), competence based assessments, leadership development, succession planning and technological enhancements. In addition, performance measures should be used to assess strategic progress;
— *Identifying lead times for recruiting, hiring and training:* Different Member States and organizations have varying requirements for these processes. The timing of their requirements need to be included in the workforce plan to ensure timely development of personnel to meet the just in time delivery of skilled personnel in the future;
— *Reviewing the workforce plan on a regular basis, e.g. quarterly:* The workforce plan should be treated as a 'living' document that requires scheduled reviews and updates. This becomes more important as the labour markets change and workforce attrition impacts occur differently than assumed in the existing workforce plan.

5.2.2. Nuclear organization specific issues and approaches

For nuclear facility operating organizations, workforce planning is particularly important for several reasons:

— It can be used to assess the extent to which the current workforce can be effectively utilized for the commissioning and operation of planned facilities;
— It can provide a systematic structure within which to evaluate alternative designs from the HR perspective;
— It can help to identify expected gaps between the competence of the existing workforce and those that will be needed based on plans for the future;
— It can assist in developing a long term strategy for the recruitment, training and employment of future staff.

Workforce planning and replacement of personnel addresses attrition in critical knowledge areas and skills/abilities gaps which may occur as a result of process improvements, technology advancements and changing business needs. A maturing workforce and increased competition for critical skill sets requires

nuclear facility management to focus on workforce planning; this may include developing and maintaining critical skills, the retention of institutional knowledge, and recruiting and training new talent. Workforce planning includes the following:

— Forecasting attrition (retirement and other terminations);
— Identifying short term labour requirements for special activities, e.g. large capital projects such as refurbishment of nuclear facilities, or steam generator or vessel head replacements at nuclear power plants;
— Timing of new recruitment (just in time replacement; effective transfer of knowledge);
— Identification of current and emerging skill needs;
— Managing labour costs;
— Developing long term staffing plans.

When planning for a nuclear power programme or when considering the expansion of an existing nuclear power programme, it is important to consider the organization of HR for all of the activities needed to implement the programme. Such forward thinking will ensure that decisions regarding the technology selected fully consider HR impacts (and associated costs) for each alternative. Appendix I provides additional information regarding HR for initiating a nuclear power programme. The IAEA also supports Member States considering workforce planning for nuclear power. Thus, readers are encouraged to check the IAEA web site for recent publications on workforce planning to support new nuclear power programmes.

Many existing nuclear facilities were put into operation in the 1970s. Thus, the age profile for these facilities is unusual, generally having an older workforce than other industrial facilities. This necessitates the replacement, in a relatively short period, of much of the experienced workforce. This situation presents particularly difficult challenges, including means of maintaining the safety culture of the organization and means of transferring knowledge to the next generation. Consideration must also be given that later generations often have different priorities, and work and learn differently than their predecessors.

Multi-skill training is the term used to describe training, usually for technicians and crafts persons, to learn and perform several skills in more than one area, for example in both mechanical and electrical engineering. By broadening employees' skills, reductions can be achieved in delays, errors and interruptions to work processes, often caused when only a single-skill employee is available. Employees, who learn new skills while making the most of current ones, result in a workforce that is more flexible and more efficient. To

implement multi-skill training requires that entry level training programmes for newly recruited technicians be redesigned. Additionally, operating organizations need to work with technical training schools to enhance their curricula and, thereby, better prepare their graduates for entry level technician positions.

Employee development methods that have been found to be effective in the nuclear industry include:

— Job rotation, including rotating top performers to assignments as instructors/trainers;
— Deputy/assistant positions, particularly for managers;
— Participation in assessment teams, including external assessments and benchmarking visits;
— Participation in short courses or workshops;
— Assignments to project teams;
— Training in supplier facilities, particularly for a first of a kind of facility or the first facility with a particular design in a Member State or organization.

5.2.3. Succession planning

Succession planning is the process of identifying and preparing suitable employees through mentoring, training and job rotation, to replace key personnel within an organization, either as their employment terms expire or should they leave the organization unexpectedly.

Succession planning involves managers periodically identifying individuals as backups for each key position and then defining development activities for these backups to help them prepare for promotions/transfers. This is important in the nuclear industry because it can take years to develop effective managers and holders of key specialist positions. In the future, there may be a critical shortage in the nuclear industry of middle and top managers, as well as nuclear specialists with suitable experience, particularly to lead new projects.

One of the key objectives in succession planning is to create a match between the organization's future needs and the aspirations of individuals. An effective way to retain talented people is to provide them with growth opportunities that offer fresh challenges, and opportunities more promising in the organization than they might find elsewhere.

5.2.4. International considerations

Nuclear energy systems depend on many disciplines of science and engineering that constitute the range of technologies needed. International cooperation and partnerships bring opportunities to draw on a broad pool of resources without which an operating organization can struggle to maintain complete capability. International cooperation in science and development can assist with optimizing the deployment of scarce manpower and, equally important, the construction and operation of large scale research and engineering test facilities.

Companies operating on a global basis develop specialist teams that provide services to plants in many Member States. At the same time, the design and implementation of future nuclear power plants should seek to reduce the need for skilled manpower for plant operations and maintenance. Examples include designing for maintainability, the use of modularity, smart components and systems, and computer-based operator aids.

5.3. RELATIONSHIPS WITH EDUCATIONAL AND PROFESSIONAL ORGANIZATIONS

The role of education is to provide people with the capabilities to become competent members of nuclear industry organizations, after they have also completed industry and job specific training programmes. Nuclear industry managers, together with government leaders, should establish relationships and partnerships with relevant academic institutions, professional organizations and international organizations, such as the IAEA. These relationships should be used to communicate educational needs and to establish cooperation activities with the educational system. Because the education and training of a specialist who is able to operate a nuclear power plant or similar nuclear facility can take ten years or more, this cooperation should be established as early as feasible in order to secure sustainable groups of professionals for nuclear programmes.

Educational programmes should be aligned with the nuclear industry's professional standards and requirements. Mechanisms to ensure the quality of educational programmes should be established; these mechanisms may include accreditation, standardization, internships and other cooperative programmes for students at nuclear industry enterprises. They may also involve nuclear industry managers and leading specialists in teaching at educational institutions. Some Member States have government sponsored or funded vocational education and training programmes operated by academic

institutions that produce qualified technicians. These technicians typically have a basic set of qualifications and practical experience in their technical field. In this case, a nuclear industry organization needs only to provide plant specific training after the individual joins the organization.

It is important that government agencies, industry and academia collaborate nationally and internationally to create a functional framework to support education and training. This includes considering funding and planning for nuclear research being integrated with funding for education. Similarly, organizations funding nuclear R&D should ensure that education and training aspects are an integral part of research activities.

Networking of academic institutions is a key strategy for capacity building and making better use of available educational resources. There are good examples (e.g. in Europe — ENEN, and in Asia — ANENT) where universities, encouraged by international organizations, are collaborating to establish common platforms at both graduate and undergraduate levels. Establishing and supporting similar education networks is essential for other world regions such as Latin America and Africa.

It has become increasingly common for nuclear industry organizations to establish corporate universities or academies that focus on the special needs of the organization in areas such as management, leadership, soft skills and specialized technical knowledge. In some cases, these corporate universities/academies have formal relationships with the educational institutions.

There is a vital need for cooperation between industry and academic institutions in R&D, including financial and other support for graduate studies.

When a Member State embarks on a nuclear programme, it is advantageous when partnerships are established with organizations in the country of origin of the technology (e.g. regulators, government ministries, operating organizations, research institutes, universities and training centres).

In Member States with nuclear energy programmes, it is quite common that the national government supports public awareness and public communications programmes to provide objective information regarding both the risks and benefits of nuclear energy.

Feedback regarding nuclear industry personnel performance, as well as emerging needs, should be provided to educational organizations for improvement of education and identification of new educational needs. Educational institutions are recommended to solicit feedback from both past graduates and from the organizations employing them within certain periods of time after completion of an educational programme (e.g. in one and three years). Appendix II provides additional information regarding HR considerations for R&D organizations.

Highly educated people are needed for innovation, R&D in the nuclear field, for the entire life cycle of nuclear facilities and for overall capacity building. Nuclear technology education in many applications including energy, medicine, industrial instrumentation and agriculture are important. The demand for graduates exists for all organizations involved in the nuclear field (see Section 1, in particular Fig. 1) and for various peaceful activities regarding utilization of nuclear technology.

5.4. IMPACT OF CHANGES IN PROCESSES AND EQUIPMENT ON HUMAN RESOURCES

It is important that nuclear industry organizations have systematic methods in place to identify the impact of changes in technology on the industry's human resources. These systematic methods include human factors engineering and ergonomics. Examples of such changes in nuclear industry processes and equipment include:

— Transition from analogue to digital instrumentation and control systems;
— Condition-based maintenance and monitoring systems;
— Computer-based procedures, including procedures embedded in processes;
— Change of training from instructor led to computer based;
— Increased automation and remote handling.

When a nuclear facility moves from the operations phase to the decommissioning phase, there are many changes in processes and equipment. Appendix V provides additional information regarding specific HR considerations for the decommissioning phase.

5.5. IMPACT OF EXTERNAL CHANGES ON HUMAN RESOURCES

It is important to monitor changes in circumstances external to the organization that may have an impact on its human resources; typical circumstances are changes in the national and international situation in relevant businesses and industries.

With emerging competitive wholesale electricity markets, and the need to maintain and improve safety and operational performance, many organizations have determined that their culture needs to be strengthened to be able to act

quickly to improve performance, cooperation between strategic business units, work group teamwork and employee accountability; and to provide more robust coaching and better feedback processes. To be able to measure the effectiveness of culture change, organizations have to develop and implement effective measurement tools.

For example, in a number of Member States, nuclear operating organizations find that there is generally a shortage of senior managers with the competence to be effective in new, more competitive environments. In general, more mobile workforces lead to greater competition for human resources with other industries, and even competition with other Member States.

Many nuclear industry organizations have executive level managers without nuclear knowledge or experience, which emphasizes the need for helping them to understand the special hazards and risks of nuclear energy that need to be addressed in business decisions.

Increased geographic flexibility in employment will also bring with it new challenges to manage and motivate a more diverse workforce.

Corporate social responsibility is an example of an increasingly important external expectation for organizations.

6. IMPROVING INDIVIDUAL AND ORGANIZATIONAL PERFORMANCE

6.1. EXPECTATIONS FOR PERFORMANCE IMPROVEMENT

The term performance improvement, as used in this guide, is the systematic process of determining desired performance, continually monitoring performance, discovering and analysing performance gaps, designing and developing effective interventions, implementing these interventions and continually evaluating the results of improvement interventions within performance monitoring for assuring that the improvement process takes place. Both SAT, which was introduced in Section 3, and performance improvement are based on many of the same foundations. Figure 7 illustrates an example of a performance improvement model. (Experience has shown that performance improvements are more often initiated by identifying desired performance.)

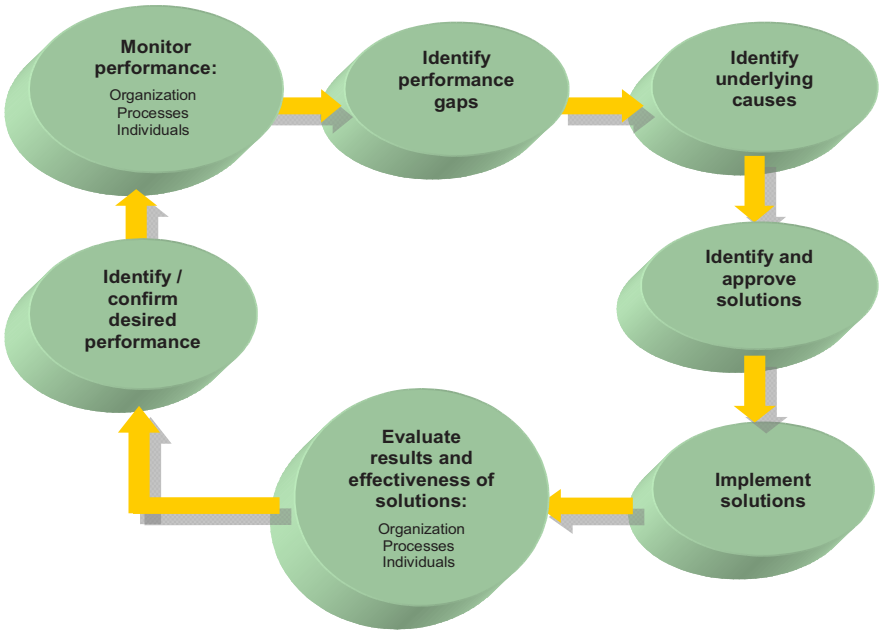

FIG. 7. Example of a performance improvement model.

The expected benefits of performance improvement are:

— Reduction in both the number, and the consequences, of events including those of safety significance;
— Increased involvement by employees in helping the organization to achieve its goals;
— Improvement of core and supporting processes in the organization;
— Attention to lower level issues before they grow into significant issues;
— Improvement in quality and safety;
— Reduction in total operating costs;
— Increased trust of stakeholders in the organization.

6.2. LEVELS OF PERFORMANCE IMPROVEMENT

In nuclear industry organizations, there are normally three levels at which performance improvement is considered:

— *Organizational level:* Dealing with strategy, organizational design/ structure and deployment of resources;

— *Process level:* Processes such as operation of the nuclear facility, waste management, ageing management, risk management, training and qualification of personnel;
— *Job level:* Focusing on the performance of job tasks.

The significance of these levels is outlined in Table 2 (see also Ref. [15]).

Performance improvement at all three levels needs to be considered. The emphasis in the nuclear industry has been on performance improvement tools that focus primarily at the job and process levels. It is clear that there are inter-dependencies among these three levels. For example, less than adequate job level performance can certainly prevent organizational goals from being achieved. Similarly, a lack of strategic planning to develop the competence needed in a new environment can result in inadequate job level performance.

The value of error prevention and reduction tools for job level performance and the value of defences for the process level should be understood and recognized by managers and personnel. The frequency of events may be significantly reduced by focusing on use of the proper error reduction tools and by focusing on reducing severity by verifying defences are in place. Individual focus (frequency) is on using the right tool at the right time to reduce the potential for error. Organizational and process focus (severity) is on defences that include, but are not limited to, engineering controls (e.g. interlocks or quality of the human–machine interface), administrative controls (e.g. quality of procedures or the corrective action process), management controls (e.g. personnel training and qualification, or manager coaching and correcting behaviours in the field) and organizational culture controls (e.g. code of professional ethics).

TABLE 2. LEVELS OF PERFORMANCE IMPROVEMENT

Level	Goals	Key performance tools	Principal management level
Organizational level	Organization goals	Strategies, design/structure, allocation of resources	Executives/senior managers
Process level	Process goals	Process improvement and effective teamwork	Middle level managers
Job level	Job goals	Job design, coaching, performance management and training	First line supervisors

6.3. INTEGRATED PERFORMANCE IMPROVEMENT

It is important to recognize the contribution of human error to significant events in the nuclear industry. Figure 8 provides an example of the contribution of human error to the occurrence of events [31].

The traditional belief has been that human error is an individual employee focused phenomenon. This belief promotes the notion that failures are introduced in the system only at the individual level. However, weaknesses in organizational processes and cultural values have contributed significantly more to the occurrence of significant nuclear facility events than have individual mistakes. Organizational weaknesses are deficiencies, often hidden, in management processes or values creating workplace conditions that can lead to an error or degrade the integrity of procedures or systems that rely on a defence in depth strategy.

Accidents result from a combination of factors that are often beyond the control of an individual. Therefore, the organizational context of individual performance is an important consideration. Event free performance in the nuclear industry requires an integrated view of performance; how well managers, supervisors and facility staff function as a team, and the alignment of processes and values in achieving the facility safety and operational goals. Human error is a normal and natural part of being human.

The frequency of errors can be reduced but never totally eliminated. The nuclear industry's focus on defence in depth is to design systems such that no individual failure, including human error, can lead to an accident. Improving individual and organizational performance in the nuclear industry needs to focus on both reducing the frequency of individual errors and minimizing the severity incurred when an error happens. Part of this is achieved by continually improving processes and organizational values, including making processes more error tolerant.

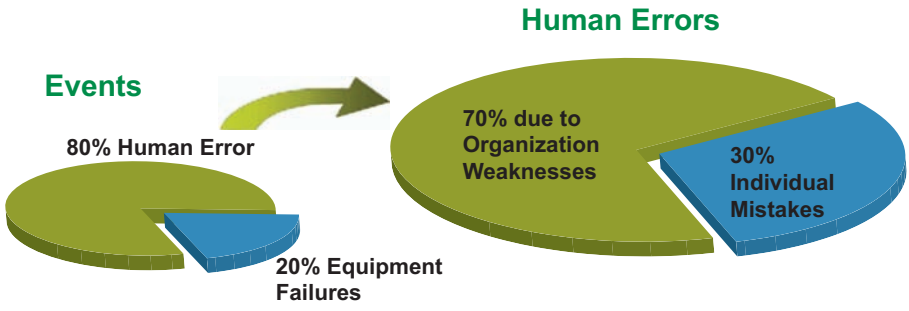

FIG. 8. Contribution of human error to the occurrence of events.

6.3.1. Role of organizational culture in performance improvement

A fundamental aspect of any organization is its culture. At a nuclear facility, a key aspect of good performance is having a strong safety culture. Safety culture has been defined by the IAEA and other nuclear safety focused organizations.

In an INSAG publication [16], safety culture was defined as:

> "that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance".

Another close definition, suggested in Ref. [17], states that:

> "an organization's values and behaviours — modelled by its leaders and internalized by its members — that serve to make nuclear safety the overriding priority".

Significant events frequently have a component where a strong safety culture did not exist. Specific principles for consideration by each nuclear facility include the following:

— Everyone is personally responsible for nuclear safety;
— Leaders demonstrate commitment to safety;
— Trust permeates the organization;
— Decision making reflects safety first;
— Nuclear technology is recognized as special and unique;
— A questioning attitude is cultivated;
— Organizational learning is embraced;
— Nuclear safety undergoes constant examination.

An organizational environment that recognizes the human potential for error and clearly defines acceptable behaviour in a consistent manner is identified as a 'just culture'. The attributes of an organization that advocates a just culture are:

— Recognition of fairness, related to the identification and resolution of personnel performance problems;
— Distinction between honest mistakes and intentional shortcuts with respect to discipline;

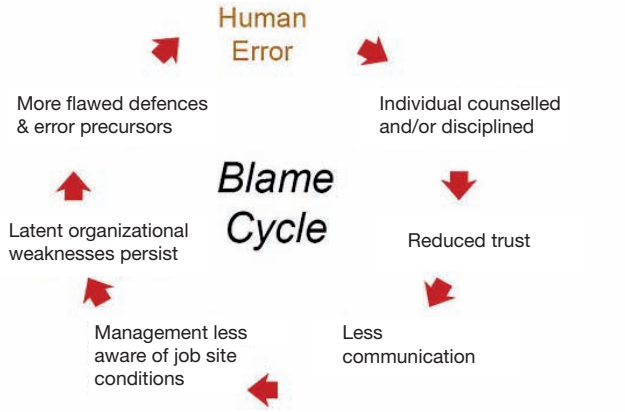

FIG. 9. Schematic of the blame cycle.

— Free flow of information across and between all levels of an organization (better known as openness and trust);
— High levels of self-reporting.

One of the important objectives of performance improvement is to reduce the negative impact on the organization of a 'blaming culture'. Negative consequences of a 'blame cycle' are shown in Fig. 9 [18].

6.3.2. Leadership role in performance improvement

It should be recognized that personal involvement and support of senior managers are crucial factors in achieving a just culture and for implementing any cultural changes in a nuclear industry organization.

The principles and desired behaviour detailed in Refs [19, 30] are important for improving performance.

The underlying principles of organizational improvement include:

— Recognizing that people are fallible;
— Predicting, managing, preventing;
— Influencing behaviour;
— Encouraging;
— Learning lessons.

The desired behaviour of an individual includes:

— Communicating to create shared understanding;
— Anticipating 'error-likely' situations;

— Confirming integrity of defences;
— Improving personal capabilities.

The desired behaviour of a leader includes:

— Eliminating organizational weaknesses;
— Facilitating open communication;
— Reinforcing desired behaviour;
— Valuing error prevention;
— Promoting teamwork;
— Serving as a behaviour role model.

The desired organizational values to be advocated by all managers and personnel should:

— Foster a culture that values prevention of events;
— Strengthen defences to prevent or mitigate errors;
— Create an environment that encourages learning and continuous improvement.

Ultimately, the attitudes and practices desired by the organization include:

— The will to communicate problems and opportunities to improve;
— A healthy uneasiness toward making mistakes;
— Intolerance of 'error traps' that place people and the facility at risk;
— Vigilance and situational awareness;
— Rigorous use of error prevention techniques.

Managers and personnel should understand a simple but important statement:

Effectively Managing Performance Leads to Significantly Lower Rates and Consequences of Undesirable Events

6.4. ORGANIZATIONAL, PROCESS AND JOB LEVEL CONSIDERATIONS

Some examples of good practices for achieving effective performance improvement at organizational, process and job levels (based upon Refs [21, 30]) are given below.

Organizational level attributes for achieving reliable performance include:

— Senior managers establish expectations for excellence in performance, safety culture and intolerance for process and workplace deficiencies. Strategic and business plans define goals, objectives, resources, performance measurements and supervision.
— Teamwork and healthy relationships result from a culture of trust, respect and fairness.
— Communication of information that can affect performance is highly valued.
— Managers routinely communicate and reinforce desired values and behaviours through observation, coaching, counselling, rewards and performance feedback. These managers also seek frequent input for performance improvement as well as trend performance.
— A process-based management system is established at the nuclear facility, and self-assessment, a corrective action programme and management of human resources are integrated into the management system (see also Section 2).

Process level attributes that contribute to reliable performance include:

— Processes are implemented as designed and are periodically assessed to eliminate weaknesses that could affect performance. Processes that are important for reliable performance include planning and scheduling, clearance tagging, configuration management, work control and use of operating experience.
— Work preparation and pre-job briefings identify critical actions and specific error prevention tools; potential human errors and their effects on the facility; contingency plans; and applicable operating experience;
— Procedures and other work documents are verified and validated for accuracy and usability. Deficiencies are corrected promptly.
— Changes in work plans and work schedules are critically reviewed for conditions that can provoke error or allow an undesirable effect on the facility.
— Initial and continuing training provides knowledge of error-prevention techniques, an understanding of their bases and importance, and reinforces the value of defences; this includes opportunities to practise using specific error prevention tools.
— Effective, corrective action programme (which might not necessarily involve root cause analysis) is used for improving processes.

— Root cause analysis — supplemented by performance improvement investigations — identifies the organizational, process and individual contributors to events.

It is especially important to undertake root cause analysis properly using a proven methodology; and to ensure that root cause analysis results are not influenced by the desire of managers to obtain certain results. Adequate root cause analysis will identify the deeper process or organizational aspects that are more related to the root of the problem that caused the event.

Job level conditions that contribute to reliable performance include:

— Goals, roles and responsibilities for the assigned task are discussed and understood before work begins;
— Assigned personnel are technically qualified for the task, and are physically and mentally ready to perform the work;
— Job site conditions are properly established to enable qualified personnel to accomplish work assignments successfully;
— Job site conditions and potential consequences are carefully evaluated to reinforce desired work behaviours, to reduce the potential for human error;
— Work preparation and pre-job briefings are conducted commensurate with the risk of the work activity;
— A variety of defence in depth measures are used at the job site, commensurate with the risk of the work activity, to reduce the probability of error, as well as to mitigate the effects of and provide for recovery from error;
— Critical steps within the task are identified and the specific error prevention tools to be used to preclude an event of consequence are discussed.

Individual values and behaviours needed for achieving reliable performance include:

— Individuals maintain situational awareness — they are watchful for conditions or activities that can have an undesirable effect on facility performance or personnel safety, and they do not proceed if faced with uncertainty;
— Procedures and other work documents are used as intended;
— Error-prevention techniques are understood, and appropriately and rigorously applied to task specific situations;

— Deficiencies and suggested improvements in processes, documents, equipment and the workplace are reported promptly.

6.5. PERFORMANCE IMPROVEMENT TOOLS

To effectively improve performance, the implementation of any solutions should consider the inclusion of effective performance improvement tools as well as incentives.

6.5.1. Error prevention techniques

Managers and employees should know the most frequent error traps and error-like situations in their area of work, and should be trained to use error-prevention techniques.

It is important to integrate performance improvement concepts and tools into work planning and work performance. This requires development and use of work controls that utilize error prevention techniques. Examples of these techniques are:

— Review of facility and equipment design;
— Work planning;
— Selection of personnel with suitable knowledge, skills, experience and attitudes;
— Use of good practices and review of lessons learned;
— Project or task preview to identify potential risks;
— Job hazard analysis;
— Situational awareness (a special procedure in the case of safety relevant activities);
— Self-checking (e.g. using the STAR technique — Stop, Think, Act, Review);
— Peer-checking (e.g. an effective four-eyes principle);
— Three-way communication;
— Use of a phonetic alphabet (corresponding to the language of the country);
— Development, use and adherence to procedures;
— Identification of critical tasks and critical steps in operation and maintenance of a nuclear facility;
— Checking off individual steps during sequences;
— Training of personnel;
— Feedback from managers through field observations;

— Qualification of personnel for performing tasks and authorization for independent work;
— A questioning attitude;
— Independent verification;
— Stating intentions before acting;
— Pre-job briefings;
— Two minute drill (short drill on the spot);
— Post-job critique;
— Reviews and assessments within the management system.

More information on error prevention techniques can be found in Refs [20–23, 32].

6.5.2. Reinforcement of desired performance

Some form of reinforcement is necessary to reward performance improvement. A well-designed and implemented personnel performance management programme can be a very effective tool for assisting performance improvement. However, it should also be recognized that such incentives can be counter-productive if not effectively implemented. For example, incentives that single out individuals for benefits based upon their individual performance can have a negative effect on the motivation of colleagues, particularly if these colleagues are convinced that this individual has received the award unjustifiably or at their expense. One useful approach in this regard is to have incentives based on work team performance, rather than individual performance. This approach can be applied equally well to managers and to other facility personnel. It is important that incentives not only to correct behaviour in the short term but also to achieve changes in the long term are carried out.

As another example, while managers' objectives should be to have positive consequences for good work and negative consequences for poor work, their actions do not always support this objective. When managers give a top performer more work to do because that individual did it well, this is an example of a commonly occurring negative consequence for individual positive performance (Fig. 10). This is often perceived by the employee as being punished for doing good work. The reverse can also happen when a manager takes away work from a person who works at a low performance level, so rewarding poor performance.

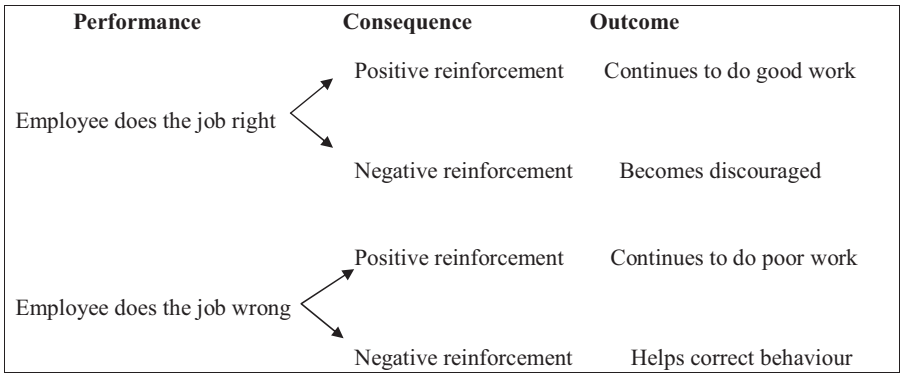

FIG. 10. Performance, consequences and outcomes.

6.6. KNOWLEDGE MANAGEMENT FOR PERFORMANCE IMPROVEMENT

Knowledge management is an important comprehensive process that supports improving performance. Knowledge management is a crucial factor for success in the nuclear industry, and should be well planned and carried out for all phases of a nuclear facility's life cycle. More information on knowledge management may be found in Refs [12, 24, 25].

7. SUMMARY

The guidance provided in this publication is primarily intended for line managers in the nuclear field; from the highest executive levels down to the first line supervisor level.

While this guidance should also be useful for those managers and specialists responsible for traditional personnel or HR functions (such as salary and employee benefits), it should be reinforced that managing human resources is a function of all of the managers of an organization, and all managers involved in the nuclear field are encouraged to use the guidance provided in this publication.

Complex technology, as well as safety, security and proliferation concerns combine to create unique challenges to recruiting, training, qualifying and

retaining the right people for the nuclear field, and to ensuring the required performance. Thus, managers in the nuclear field need to devote more funding and priority to the management of human resources than is typical for other industries.

Management of human resources should be fully integrated into the organization's management system.

Managers should demonstrate, through their performance and behaviour, their commitment to the high standards of conduct that are needed in the nuclear field.

The culture of organizations in the nuclear field needs to be one that is based on defence in depth and continual performance improvement.

Appendix I

SPECIFIC HUMAN RESOURCES CONSIDERATIONS WHEN INITIATING NUCLEAR POWER PROGRAMMES

Guidance provided in the main body of this publication applies fully to newly established nuclear power programmes. An IAEA Nuclear Energy Series guide on Milestones in the Development of a National Infrastructure for Nuclear Power [26] provides recommendations regarding essential activities and milestones for acquiring the competent human resources needed to implement an infrastructure development programme. This appendix focuses on some important aspects of HR development for the successful introduction of nuclear power programmes:

— It is not realistic to expect that a Member State or organization initiating a nuclear power programme will, at the beginning, have personnel with all the competence needed to implement the programme. The programme should include a comprehensive project for the evaluation of HR needs and for the provision of the human resources required;
— Various methods can be combined to get competent staff to introduce a new nuclear power programme:
  • Development of a national system for providing human resources;
  • Turnkey projects that allow the time and means to develop competence in the newly established organizations (see also considerations for turnkey contracts later in this appendix);
  • Recruiting competent staff for the commissioning and later stages of a nuclear facility operation;
  • Use of international networks (such as provided by the IAEA) and owners' groups (organizations or facilities having similar technologies that share experiences and even resources);
  • Partnerships with vendors;
  • Partnerships with regulatory bodies, nuclear facility operating organizations and educational institutions from other Member States;
  • Partnerships with academic and trade organizations.
— Several critical HR related factors influence decision making when new nuclear programmes and facilities are introduced; these factors include the overall educational level in the Member State, the maturity of its educational system and its readiness for necessary changes, the overall attitudes of society towards safety culture, attitudes to the acceptance of comprehensive and safety related projects, overall leadership abilities, the availability of personnel possessing sufficient project management skills

and attitudes to being an 'intelligent customer', and a readiness to involve the necessary financial, manpower and technical resources to develop the competence of the personnel of all the organizations involved, including the regulatory body and operating organization;

— The terms and conditions of employment of national personnel in the different activities (such as review of the design, construction and commissioning) should be developed by the end users to enable their personnel to acquire the necessary competencies and to transfer relevant knowledge to the operating organization personnel and other organizations involved in the nuclear power programme. However, the use of local organizations or employees in the construction of nuclear facilities, dictated by the need to minimize costs or the contract price, can lead to delays in construction or a reduction in quality. A shortage of qualified labour may be a significant issue for new nuclear facility construction projects. Early, ongoing and thorough planning should be performed to ensure that the necessary construction skilled personnel are available;
— Long term staffing plans for the required categories of managers and personnel are needed for all national organizations involved in a new nuclear power programme. The length of time and effort needed to prepare competent managers for nuclear facilities, operating organizations, regulatory bodies and technical support organizations should not be underestimated;
— The qualifications necessary for personnel commissioning and operating a nuclear facility, or for those involved in other organizations such as a regulatory body, should be identified at an early stage of the nuclear programme. These qualifications should be reflected in job descriptions for the nuclear facility and should be prepared well in advance of commissioning, not at the last moment. This requires timely development of the organizational structure; unfortunately, this does not always happen due to pressure to make the optimum use of available staff or because of poor initial identification of the functions of the operating organization, nuclear facility or regulatory body;
— During the early planning stages of a nuclear facility programme, it is important to consider the strategy that will be adopted regarding vendor support, both at the outset of the programme and at later stages of plant operation. The numbers and qualifications of personnel required for operation and maintenance of a nuclear facility are strongly influenced by the outsourcing strategy of the operating organization;

— At an early stage of the nuclear programme, a strategy for the development and implementation of a training system for nuclear facility personnel should be identified in a document approved by the end user senior managers;
— For newly-established training systems, it is recommended that experienced consultants are involved to procure assistance to develop a strategy for the training system and to identify requirements for its various elements;
— It is important that the initial training of nuclear facility personnel and delivery of SAT-based training programmes and training materials, as well as essential training tools, are included in the tender documentation from a potential vendor. The analysis of training needs should also identify appropriate continuing training programmes that should be in place before operation of the nuclear facility begins;
— A critical issue for the development and implementation of training materials and tools is the availability of national regulations, a safety analysis report, adequate nuclear facility management and operating procedures, technical manuals for equipment, an agreed and frozen organizational structure and job descriptions for the nuclear facility personnel. This issue should be taken into account very seriously when preparing the overall schedule for the introduction of a new nuclear facility and when developing a training system;
— The following training and HR management considerations are particularly important for turnkey nuclear facility projects:
  • The scope of the training system supplied by the vendor should be identified, assuring that the scope corresponds to the established strategy, and those elements of the training system that are not included in that scope are understood and will be supplied through other mechanisms;
  • SAT based training should be required and the vendor's personnel need to be competent in SAT;
  • The transfer of training know-how should be included in the scope of the vendor's specification;
  • Training programmes and materials should be structured and developed in such a way that they can be used and maintained according to the established training policies, strategy and agreed training and HR management procedures;
  • If authorization or licensing of personnel is required, the regulations, responsibilities and mechanisms should be clearly identified;

- Responsibilities for providing and managing training, and for qualification of personnel during construction and commissioning should be clearly defined;
- The end user should establish the training and HR management organizations in a timely manner to support all activities associated with the required recruitment, training development and implementation, in addition to learning from participation in related projects;
- The terminology and nomenclature for systems, components and operations used for training should be the same as used in the nuclear facility technical documentation;
- Training opportunities during acceptance of equipment and commissioning of the nuclear facility should be defined for various categories of end user personnel including managers, quality assurance personnel and future operators;
- The responsibilities, technical specification and schedule for providing comprehensive and important training tools, such as a full scope control room simulator, should be defined. The responsibilities and requirements for acceptance testing of the training tools should also be defined. The end user should pay attention to the availability of acceptance testing procedures and testing teams;
- The end user should establish a sound mechanism for evaluating the quality and effectiveness of training. Quality plans and evaluation procedures, as well as competent personnel employed by the end user, should be available, although services to assist in these activities may be outsourced.

— All major elements of the training should be completed before commissioning, to allow personnel to gain experience though participation in the commissioning of the nuclear facility;

— A key lesson learned regarding commissioning of a nuclear facility is the importance of having a plant referenced, full scope control room simulator available well in advance of nuclear facility operation. This simulator not only provides a unique tool for training nuclear facility control room personnel, but is also important for tasks such as: normal, abnormal and emergency operating procedure development and validation; development and validation of commissioning tests; validation of digital control systems; and training of other plant personnel. For many new nuclear facility projects, a full scope simulator is provided as part of supplying the nuclear facility package. Integrating the simulator development and training schedule with the overall commissioning

schedule is very important. The completion of required simulator training may be on the critical path for commissioning;

— There is a risk of a loss of critical knowledge during the implementation of a newly established nuclear power programme. This could be caused by delays in fulfilling contractual obligations as a result of a lack of resources (e.g. funds, staff), political reasons or deficiencies in the design. Several other risks include the attrition of personnel caused by migration elsewhere or the promotion/transfer of personnel to other parts of the organization. For example, personnel trained and qualified for the nuclear field may find better jobs in other industries or even in other Member States. A knowledge management process should be established from the very beginning of implementing the new nuclear power programme.

More information regarding this area can be found in Ref. [27].

Appendix II

SPECIFIC HUMAN RESOURCES CONSIDERATIONS FOR RESEARCH, DESIGN AND DEVELOPMENT ORGANIZATIONS

Talented researchers entering the nuclear R&D field are scarce and, hence, replacement of retiring knowledgeable personnel is difficult. Providing first rate facilities and being well-positioned within the international R&D scene are key factors for R&D organizations to attract and retain highly qualified researchers.

The challenges to nuclear R&D have become immense during recent decades:

— An increasing need for more advanced nuclear R&D, both capital and resource intensive, resulting in a need for funding and risk sharing of such R&D on national and international levels;
— A growing consolidation in the nuclear field, including the nuclear power industry (e.g. nuclear facilities, vendors and fuel cycle services) results in an increasing need for nuclear R&D organizations to be centres of excellence, providing the very best knowledge and services to the industry;
— Governments seek more and more public–private partnerships to increase the amounts of public money spent on R&D and at the same time include an inherent selection process in funding practical R&D with more limited government specific R&D relating to governmental policy choices (e.g. proliferation);
— Given that nuclear R&D organizations operate in a more international, collaborative environment, including a shared R&D facility base as so called user facilities, the way in which knowledge within a nuclear R&D organization is collected and used crucially becomes a strategic element allowing organizations to uniquely position themselves within this international nuclear R&D scene.

However, it is clear that no Member States can or should be totally 'self-reliant' with regard to research, design and development in the field of nuclear science and technology. Particularly, where a Member State is initially adopting nuclear energy, it is generally necessary to gain research, design and development expertise from others, especially from vendors, regulatory bodies and technical support organizations that have experience with the particular technology selected. However, over time, research, design and development capabilities should be developed, consistent with the overall national needs and

infrastructure capabilities. It is desirable not to duplicate existing R&D facilities and programmes, but rather to complement them, and add to the international store of information and knowledge regarding nuclear energy.

Both proliferation issues and intellectual property considerations are constraints in sharing information regarding nuclear technology from an international perspective. Each Member State, R&D organization or corporation, may have incongruent policies that complicate the sharing of knowledge. However, the boundaries of these barriers should be clearly defined and not extended unnecessarily.

Education in nuclear science and technology is closely linked to R&D, both as a source for researchers and also because basic research, in particular, often comes through university programmes. Additionally, nuclear energy researchers need to maintain a link with these academic institutions in order to maintain and enhance their competence throughout their careers. It is important that staff of academic institutions are involved in R&D, contributing to the nuclear industry's R&D while developing their own competence. It is equally important that leading researchers and designers are involved in lecturing students, not only transferring their valuable knowledge and experience but also serving as role models for new generations.

In most cases, researchers, compared to personnel operating and maintaining nuclear facilities, have a greater in-depth and specific knowledge than their nuclear facility counterparts, though over a narrower range of knowledge, often focussed on a detailed understanding of why and how things happen. This, in general, provides a complementary aspect to R&D at nuclear facilities.

Experience indicates the benefits that can be realized by nuclear industry operating organization personnel being involved in applying knowledge gained from research to the design, operation and maintenance of a nuclear facility. Such application is a way for employees to improve their competence and also to maintain the knowledge base at the facility.

R&D organization management and technical staff should be aware of safety issues of concern for nuclear facilities and nuclear activities, and should be knowledgeable of and have a positive attitude towards safety culture, and should have access to worldwide operating experience of nuclear facilities. R&D personnel should be capable, motivated and appropriately managed to continuously collect and analyse information from a range of sources.

R&D staff should know why design requirements and industry regulations are established and be aware of and understand the design basis; this is especially important while new engineering solutions, innovations or new designs are being suggested.

The appropriate competence of the R&D organization staff should fully support the R&D services required by the nuclear facilities throughout their entire life cycle, including any necessary safety assessments, upgrades and modernization projects. The transfer of knowledge to new generations of R&D personnel has to be ensured, together with maintaining the appropriate organizational culture. Documents and data management, as well as thought-out knowledge management, should be fully instigated for the R&D organizations. The R&D staff should have access to the configuration management (CM) system data of the nuclear facility and they should understand CM concepts.

To build and maintain the R&D staff competence, to ensure the adequate working environment for the staff and to improve their performance, access to the necessary R&D facilities and tools should be provided. Examples are research reactors, computer-aided design systems, computer codes and analysers, databases and expert systems.

It is worthwhile considering the establishment, using the resources of R&D organizations and academic institutions of so called centres of excellence to undertake the exemplary education and R&D programmes. Such centres promote innovative research, teaching and learning practices that establish themselves as leaders in the Member State or internationally. Because of their strategic location or the absence of similar programmes in other Member States, the centres may be uniquely positioned to be leaders in:

— Conducting nationally recognized R&D and forging partnerships to serve the needs of industry;
— Helping to shape related public policies;
— Enriching the practice of teaching in a particular discipline;
— Attracting and retaining students who will earn graduate degrees and become contributors to that discipline and the nuclear industry.

Appendix III

SPECIFIC HUMAN RESOURCES CONSIDERATIONS FOR NUCLEAR REGULATORY BODIES

The guidance provided in the main body of this publication — including considerations for the management of human resources, training and performance improvement — applies equally to nuclear regulatory bodies. The IAEA Safety Standards provide information with regard to staffing, competence, HR and training considerations for nuclear regulatory bodies. Even though the IAEA Safety Series publications on the legal and governmental infrastructure for nuclear, radiation, radioactive waste and transport safety requirements [28], and on the organization and staffing of the regulatory body for nuclear facilities [29] address the elements of HR for regulatory bodies, further aspects, as outlined below, should be focused on:

— Functions of a regulatory body include authorization, review and assessment, inspection, enforcement, development of regulations and guides, R&D, emergency preparedness and international cooperation. To fulfil these functions, the regulatory body should have a full time staff capable of either performing regulatory reviews and assessments or evaluating any assessments performed for it by consultants. One of the most important core competencies of the regulatory body, to be able to make the necessary regulatory decisions, is the ability to judge, on a risk-informed basis, the overall safety of facilities and activities. Even if outsourcing some services, the regulatory body should remain an 'intelligent customer';
— Regulatory independence is extremely important. Such independence involves the competence aspects as well as organizational independence (based on the Convention on Nuclear Safety). It is essential that the regulatory body is independent in all decision making processes and unequivocally has independent technical expertise in the areas relevant to its responsibilities for safety;
— To competently carry out the regulatory responsibilities to oversee the safety of nuclear facilities and activities, nuclear regulatory personnel must have sufficient knowledge of the specific facilities, equipment, processes and activities they regulate, inspect, assess or license, as well as knowledge of the criteria, techniques and mechanics of inspection, assessing, reporting and licensing;

— Adequate numbers of regulatory body employees have to be in post to viably support changing and growing nuclear industries. For newly established nuclear power programmes, timely availability of competent regulatory body personnel is essential. Staffing plans to provide and maintain regulatory technical capabilities should be in place and periodically reviewed in a systematic manner. A balance between technical and non-technical or managerial positions should be assured. Long term staffing plans of the regulatory body should align with the nuclear industry's plans for new facility projects, long term operation, licence renewal and decommissioning of nuclear facilities;
— Responsive regulatory capability is needed for new technology applications (such as the introduction of advanced digital control systems, new information technology concepts, information technology security, nuclear material security, radiation source security and source tracking systems). Training and development of the regulatory body staff should be provided to ensure that they are able to use this updated knowledge for their duties applied to technological developments and new safety principles, concepts and challenges such as aircraft impact, terrorism threats and new fuel designs;
— Attractiveness of employment within the regulatory body, especially for the technical staff, is an important factor to ensure the overall competence and capabilities of the body. In some Member States, the regulatory bodies are among the most prestigious governmental organizations while in other Member States they are less so because of safety related negative associations. The working environment within the regulatory bodies should be positive for managers and for technical staff to attract and retain personnel. To be able to compete with the nuclear facilities and other industry sectors for limited human resources and to maintain parity across the nuclear industry, Member State governments should provide their regulatory bodies with sufficient funding, career development opportunities and training resources; they should also be in a position to be able to offer industry comparable compensation and benefits to assure the attractiveness of employment in the regulatory bodies;
— Important characteristics of the competencies of regulatory body personnel are their attitudes and professional ethics. These should be focused on during the selection of personnel and further reinforced during job performance. Compromised professionalism of regulatory body personnel inevitably leads, sooner or later, to a decrease in nuclear facility safety and an increased potential for major accidents;

— Political influence on regulatory body personnel and economic limitations of nuclear industry facilities must not be permitted to influence the attitudes of the regulatory body personnel;
— Participation of the regulatory body personnel, including functional technical employees, in national, regional and international activities and programmes should be provided continuously to prevent those personnel from becoming isolated and insular; such a policy also facilitates the development of new or alternative approaches to work, and for sharing good practices and lessons learned. Collaborative training with industry and universities is also a helpful tool;
— Loss of critical knowledge due to the attrition (caused, for example, by retirements, promotions and transfers, or insufficient motivation including underpaid jobs) is a real risk for regulatory bodies. The problem of an ageing workforce in regulatory bodies should be addressed through knowledge management initiatives that include taking advantage of staffing plans, possible recruiting of technical retirees for staff support, knowledge preservation and training. In some cases, this may require legislation to change laws regarding post-retirement employment as well as innovative employment programmes that address quality of life factors other than mere remuneration.

Appendix IV

SPECIFIC HUMAN RESOURCES CONSIDERATIONS FOR EXTERNAL TECHNICAL SUPPORT ORGANIZATIONS AND OTHER CONTRACTORS

There is a wide spectrum of organizations rendering technical support services and serving as contractors in the nuclear field.

External technical support organizations (TSOs) are often used as contractors to perform tasks that are of a specialized or temporary nature where either it is not feasible to hire or maintain full time nuclear facility staff, or specialized knowledge is involved. Examples of nuclear facility activities that can be assigned to external TSOs/contractors are:

— Design of nuclear facilities;
— Nuclear engineering, including fuel, shielding and core physics;
— Information technology services;
— Mechanical engineering;
— Electrical engineering;
— Chemistry;
— Maintenance;
— Outages;
— Non-destructive testing;
— Modernization of instrumentation and control systems;
— Participation in design change engineering packages;
— Commissioning of nuclear facilities;
— Decommissioning of nuclear facilities;
— Human factors considerations;
— Training;
— Development of nuclear facility managers;
— Performance inspection;
— Independent nuclear oversight;
— Physical protection;
— Support in establishing management systems (including support in establishing quality assurance programmes).

TSO/contractor personnel are often used to provide essential services to nuclear facilities during planned outages or for projects involving major upgrading or refurbishment of a facility. TSO/contractor personnel are often expected to act as members of problem solving teams and promoters of

innovation. Thus, TSO staff should have the necessary soft skills which facilitate human interaction.

It is the responsibility of nuclear facility management to ensure that TSO/contractor personnel are competent and qualified for their assigned tasks.

For TSO/contractor personnel that are to have unescorted access to a nuclear facility, general employee training or site access training is provided.

In the case where TSO/contractor personnel are performing the same tasks as those of plant personnel, the same job specific training and qualification requirements should apply.

Where TSO/contractor personnel are performing tasks not generally assigned to facility personnel, suitable job specific training and qualification programmes should be provided, normally by the relevant TSO/contractor organization, subject to audit by the nuclear facility.

TSO/contractor personnel competence should be formally assessed; qualifications should be documented and then carefully reviewed by the nuclear facility personnel. A regulator or independent inspection organization may also be called upon to assess the adequacy of qualifications.

The respective roles and responsibilities of TSO/contractor personnel and of nuclear facility personnel should be clearly defined, understood and documented.

A nuclear facility operating organization must have adequate personnel possessing the knowledge, skills and attitudes necessary to supervise and evaluate the work of all contractors. Several serious incidents have occurred at nuclear facilities as a result of the operating organization not adequately monitoring the performance of TSO/contractor personnel.

Nuclear facility and equipment vendors are a significant category of contractors in the nuclear field. The world nuclear market is reviving for nuclear power plant vendors, major contractors and TSOs which are dedicated to the design and construction of nuclear power plants and research reactors; the areas involved include engineering, instrumentation and control modernization, maintenance and repair services, component manufacture and the supply of nuclear fuel.

The competition for new-build projects is intense, and customers are more demanding than previously and have new expectations. New projects in progress show that safety requirements are increasing and that safety authorities will accept no compromises and will request more and more formalized evidence of compliance. Accordingly, talent requirements are growing in terms of technical expertise as well as management skills.

These new challenges ahead should be met by systematic workforce planning, based on the expected development of the expanding business; this will entail specifying the skills, numbers and locations of employees required to

accomplish the mission and objectives of the organization serving as a nuclear facility vendor or major contractor. Such specification should then be used to systematically design, develop and implement training and coaching programmes in order to prepare newly recruited people for their future positions. In this regard, knowledge management programmes are important, and may be more complicated, for the design, manufacturing, construction and commissioning organizations, compared with operating nuclear facilities. The goal is not only to attract, retain and develop the best talents, but also to transfer knowledge from the older, very experienced personnel to the leaders of tomorrow.

The personnel requirements for a company serving as a vendor or TSO or major contractor are largely defined by the type and design of the nuclear facility (including the type and design of the nuclear power plant).

Ideally, the specific requirements for the personnel should be stipulated by the nuclear facility designer, because the designer understands the design basis and requirements for personnel competence. This is particularly valid for the requirements established for personnel involved in nuclear facility construction and commissioning activities.

When designing, manufacturing, constructing, assembling and commissioning, operating and maintaining a nuclear facility and its equipment, all personnel involved should comply with the requirements established in the regulations (rules) for the design and safe operation of the nuclear facility equipment, including the requirements for personnel competence and training.

Senior managers, engineering staff and workers involved in the design, manufacturing, construction and commissioning of nuclear facility equipment should be tested to verify that they possess the required knowledge of relevant regulations and task specific knowledge. In addition, their performance should be evaluated and skills tested if appropriate. The facility, in its quality assurance programme, should state the requirements needed to verify the competence of contractor personnel, and should also audit the contractor's personnel competence and qualification records.

Requirements for personnel to be permitted to participate in construction, assembly and commissioning work should also consider age limits, medical fitness (examination) and fulfillment of training and language requirements.

It is important to verify that design, manufacturing, construction and commissioning of nuclear facility equipment are performed by competent contractors having the necessary qualified personnel, engineering and inspection services, and technical means required for carrying out the activities, subject to a contractual agreement. It should also be verified that for specific activities that require a licence duly issued by a regulatory authority, the contractor possesses a current licence.

Appendix V

SPECIFIC ISSUES OF TRAINING FOR DECOMMISSIONING ACTIVITIES

Training is one of the essential tools required to achieve a successful transition from the operating phase of a nuclear facility to the decommissioning phase, and to implementing the decommissioning strategy. The training requirements, however, depend, to a large extent, on a number of factors including the:

- Decommissioning strategy selected;
- Role of the former plant operating organization in decommissioning;
- Period elapsing between plant shutdown and the initiation of active decommissioning;
- Foreseen duration of various phases of decommissioning (e.g. dismantling, safe enclosure) and the time intervals between them;
- Innovative versus routine technologies related to specific decommissioning activities;
- Necessity to re-train the personnel in relatively short periods of time in accordance with the decommissioning plan;
- Existence of many unique activities;
- Numbers of people in each of the groups training for specific activities;
- Involvement of contractors;
- Experience of working in a radioactive environment;
- Capability to deal with non-radiological risks;
- Changes to legislation and regulations creating new training requirements;
- Potential loss of confidence in job security and future stable work opportunities compared to the operational phase.

The following key recommendations should be taken into account to ensure, at all times, the competence of personnel involved in the decommissioning of nuclear facilities:

- Staff should be prepared for reassignments;
- Facility knowledge retention and training should be planned;
- Special attention should be paid to the competence of the decommissioning management team;

— Essential relationships should be understood and considered between resource management, attitudes, motivation, training, change management and performance;
— Changes of emphasis in the training requirements for operational versus decommissioning activities should be taken into account;
— Knowledge management for decommissioning should be established and training should be viewed as a key tool for the transfer of knowledge;
— Training needs of all stakeholders (e.g. senior management, licensing authorities, the public, members of the press, line managers, professional staff and all employees) should be identified and satisfied;
— Training needs analysis should include a job hazard analysis;
— A graded approach to the application of SAT to decommissioning training should be considered and used if appropriate;
— The needs for specialized training facilities and tools for decommissioning training should be identified;
— Decommissioning project managers should develop and communicate to the staff a vision for the integrated management of human resources, including personnel training.

More information regarding this area can be found in Ref. [4].

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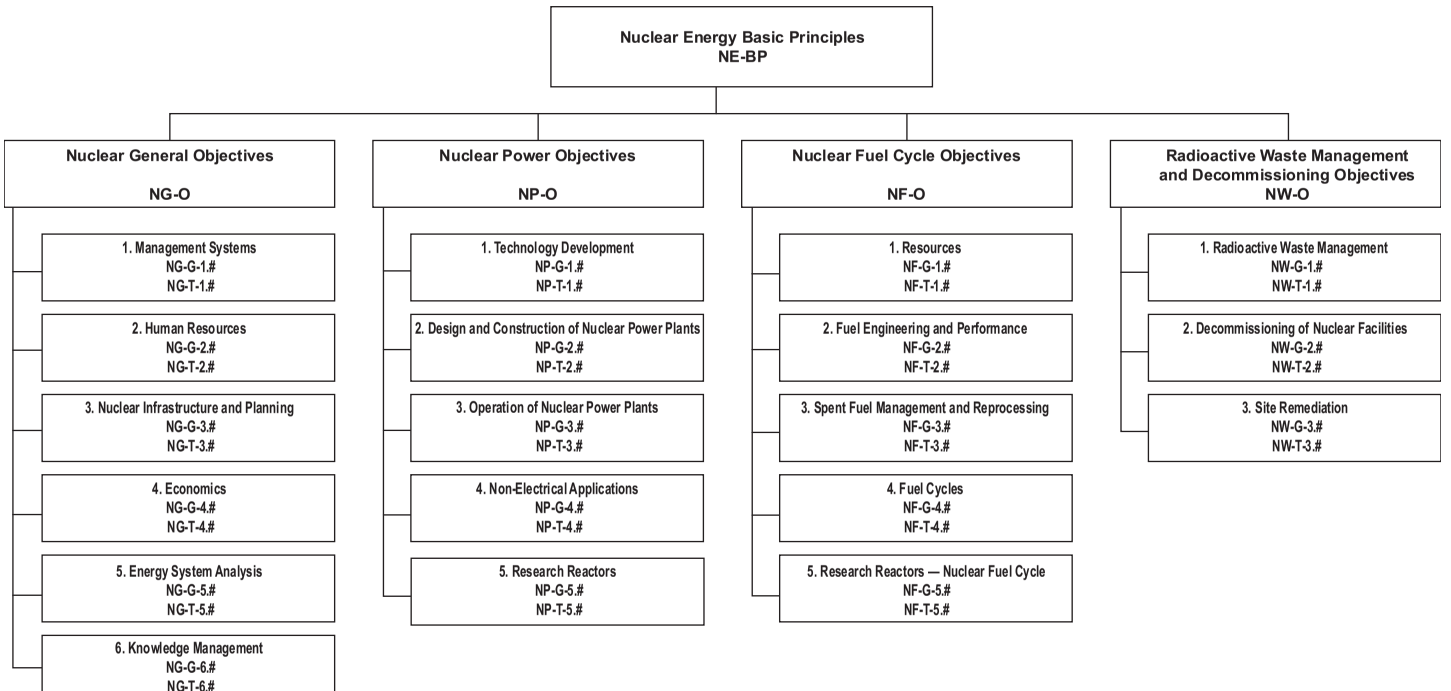

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