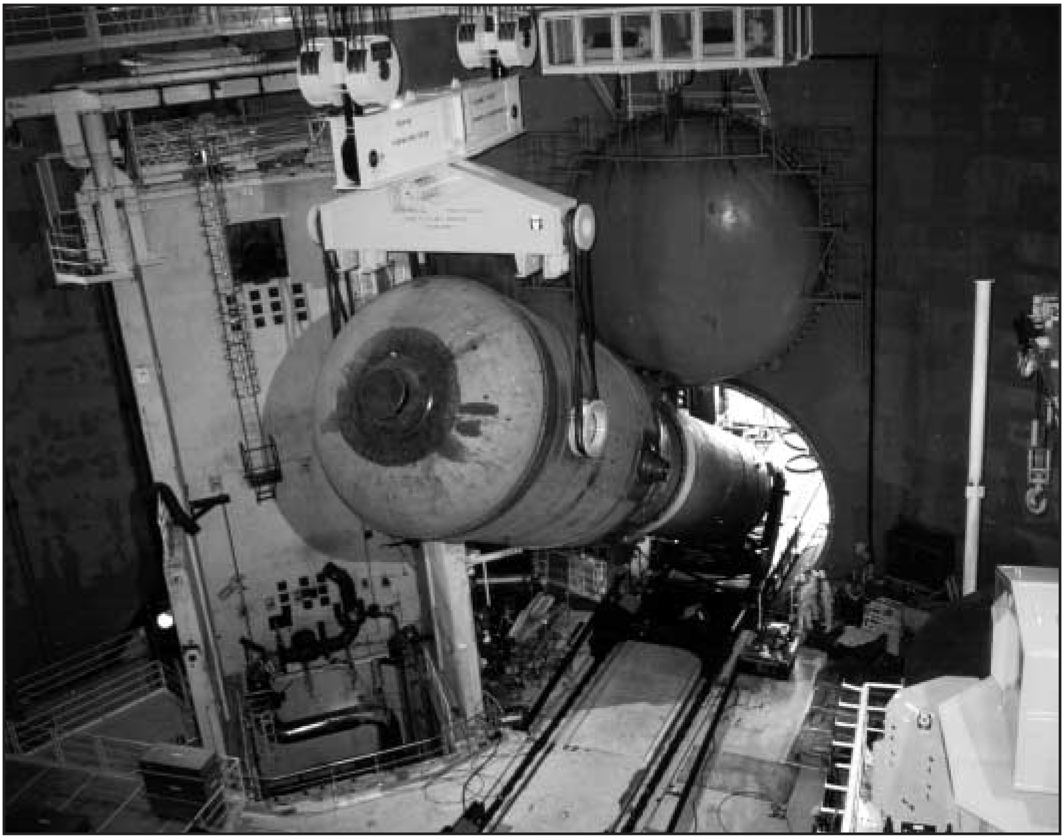

TECHNICAL REPORTS SERIES No. **399**

Organization and Management for Decommissioning of Large Nuclear Facilities

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 2000

ORGANIZATION AND MANAGEMENT FOR DECOMMISSIONING OF LARGE NUCLEAR FACILITIES

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FOREWORD

Decommissioning of nuclear facilities is a process involving activities such as radiological characterization, decontamination, dismantling of plant equipment and facilities, and handling of waste and other materials. Many organizational and management needs arise during the course of decommissioning projects. Factors such as schedule, work progress, and the outcome of regulatory and other interfaces may influence project planning and implementation.

Published information and guidance on management and organizational aspects of decommissioning are scarce in comparison with those on technological aspects. Guidance on organizational aspects may lead to better decision making, reductions in time and resources, lower doses to the workers and reduced impact on public health, safety and the environment. An IAEA Technical Report (TRS No. 351) deals with planning and management aspects for decommissioning research reactors and other small nuclear facilities. In other IAEA publications, planning and management is dealt with as one part of the overall decommissioning project. With the growing experience in the decommissioning of large nuclear installations, including the completion of some large scale decommissioning projects over the last several years, it is timely to gather and consolidate in a dedicated report the experience available globally on the management and organizational aspects of decommissioning. This technical report gives guidance and examples for all Member States involved in decommissioning large nuclear facilities on the organization and management requirements and practices.

A Technical Committee Meeting on the present subject was held in Vienna from 7 to 11 September 1998. The meeting was attended by thirteen experts from seven Member States. The participants discussed and revised a preliminary report written by consultants from Canada, Czech Republic, United Kingdom, United States of America, and the IAEA Scientific Secretary, M. Laraia of the Division of Nuclear Fuel Cycle and Waste Technology. After the Technical Committee Meeting the text was revised by the IAEA Secretariat, with the assistance of four outside consultants from Belgium, Japan, the Netherlands and the United Kingdom.

CONTENTS

1. INTRODUCTION

1.1. BACKGROUND

For nuclear facilities, decommissioning is the final phase in the life-cycle after siting, design, construction, commissioning and operation. It is a complex process involving operations such as detailed surveys, decontamination and dismantling of plant equipment and facilities, demolition of buildings and structures, and management of resulting waste and other materials, whilst taking into account aspects of health and safety of the operating personnel and the general public, and protection of the environment.

Careful planning and management is essential to ensure that decommissioning is accomplished in a safe and cost effective manner. It should be noted that published information on organizational aspects of decommissioning is scarce in comparison with that on technological aspects. Reasons for this situation may be due to overemphasizing the technical aspects of decommissioning to the detriment of the organizational ones, or due to specific political or socioeconomic conditions in any given country. Guidance on organizational aspects may lead to better decision making, reductions in time and resources, lower doses to the workers and reduced impact on public health and the environment.

An IAEA Technical Report [1] dealt with planning and management aspects for decommissioning research reactors and other small nuclear facilities. In other IAEA publications [2–5], planning and management was dealt with as one part of the overall decommissioning project. With the growing experience in decommissioning of large nuclear facilities, including the completion of some large scale decommissioning projects over the last few years, it is appropriate to gather and consolidate, in a dedicated report, the experience available globally on organizational aspects of decommissioning.

1.2. OBJECTIVE

The objective of this report is to provide information and guidance on the organization and management aspects for the decommissioning of large nuclear facilities which will be useful for licensees responsible for discharging these responsibilities. The information contained in the report may also be useful to policy makers, regulatory bodies and other organizations interested in the planning and management of decommissioning.

1.3. SCOPE

In this report, the term ‘decommissioning’ refers to those actions that are taken at the end of the useful life of a nuclear facility in withdrawing it from service with adequate regard for the health and safety of workers and members of the public and for the protection of the environment. The term ‘large nuclear facilities’ involves nuclear power plants, large nuclear research reactors and other fuel cycle facilities such as reprocessing plants, fuel conversion, fabrication and enrichment plants, as well as spent fuel storage and waste management plants. Information on the planning and management for decommissioning of smaller research reactors or other small nuclear facilities can be found elsewhere [1].

The report covers organizational aspects of decommissioning and describes factors relevant to the planning and management of a decommissioning project. It identifies the general issues to be addressed and provides an overview of organizational activities necessary to manage a decommissioning project in a safe, timely and cost effective manner. There are a number of facilities that present special cases and include those which have undergone a major accident as well as uranium mines and mills and radioactive waste repositories. These facilities are not dealt with in this report.

1.4. STRUCTURE

This report is structured as follows:

Section 1 contains background information, objectives and scope of the document. In Section 2 considerations important for decommissioning management are discussed which could affect the organization. Section 3 deals with the management for active phases of decommissioning and provides a discussion on the organization of the decommissioning management team. Section 4 gives an overview of the decommissioning planning and approval process. Section 5 provides information on quality assurance issues relevant to decommissioning. Management of decommissioning wastes is briefly discussed in Section 6. Responsibilities and qualifications of the decommissioning management team are dealt with in Section 7. Conclusions and recommendations are given in Section 8. The report is supplemented with references, Appendix 1 giving details on recent experience on data management, a glossary, and national annexes, some of which indicate how the principles set out in the main report are to be utilized in different countries, and some of which are real examples of arrangements used in decommissioning projects. A list of drafting and reviewing bodies is also included.

2. IMPORTANT CONSIDERATIONS FOR DECOMMISSIONING MANAGEMENT

The objective of decommissioning is the reduction of risk, ultimately leading to unrestricted release of the site in a safe and cost effective manner. In order to achieve this goal, there are a number of important considerations that should be factored into the development of a decommissioning project including a dedicated management organization. These considerations are discussed below.

2.1. PLANNING STRATEGY

It is agreed that planning for decommissioning begins during the design of the facility and continues during its construction and throughout its operational life. In the case of a facility that is shut down without decommissioning plan, such a plan should be prepared without undue delay. Along with other objectives, this earlier planning would provide a sound basis for decommissioning cost estimation and funding provisions. However, the reasons for eventual plant shutdown could have implications for the decommissioning planning strategy. The reasons for decommissioning can be technical, economic, safety related or political.

Among the technical reasons, obsolete technologies and out of date equipment play the major role. Uneconomic operation may represent another reason for facility closure and subsequent decommissioning (e.g., the operating costs are too high). The closure of a facility for safety reasons could occur if, for example, the regulatory body requires conformance with new standards and these improvements cannot be justified economically. In addition, the facility may have undergone a serious accident making refurbishment and restart too costly.

Regardless of why a facility is permanently shut down, decommissioning may be carried out in one continuous operation following shutdown or in a series of discrete operations or stages (phased decommissioning). Some previous IAEA documents have referred to three discrete stages of decommissioning [1, 2, 5]. As a result of recent decommissioning experience, some countries have adapted the IAEA definitions of the stages.

The choice of the strategy for decommissioning of a nuclear facility is of great importance. A number of factors will have to be considered. Selection of a specific decommissioning option will define the timing and sequence of decommissioning activities.

Decommissioning options may range from immediate dismantling and removal of all radioactive materials from the site to an option of, in special cases, in situ disposal under which a reactor is entombed. There are many intermediate options; one of these consists of a minimum degree of early dismantling and conversion of the plant to safe enclosure, before final dismantling. The safe enclosure option for a defined period of time is known as deferred dismantling. Similarly, options may include partial dismantling of the plant, usually of externally accessible areas while placing others, for example the reactor vessel and internals, into a safe enclosure state. There are several important elements influencing the choice of a decommissioning strategy; one is the availability of disposal routes for any radioactive waste generated and the agreement from the waste disposal organization. This agreement may include timing, costs and the requirement for waste acceptance. Another element is the issue of spent fuel management (see later in Section 2).

A generalized decommissioning strategy can be characterized as follows:

- Carry out a post-operational cleanout and achieve the safe enclosure stage of decommissioning as soon as possible after normal operations have ceased so as to minimize future care and maintenance costs and maximize the use of operational experience.
- Dismantle more fully if this is justified by safety, environmental protection, for economic or social arguments or to make maximum use of existing expertise.
- Defer dismantling in other cases until disposal routes for the radioactive wastes generated are available, or if this reduces the total dose through radioactive decay.

As a general rule for radioactive decay considerations, alpha contaminated facilities should be decontaminated and dismantled soon after closure, whereas facilities involving beta and gamma contaminated or activated materials often benefit from radioactive decay and hence deferral of the decommissioning work.

For facilities such as nuclear power plants, it may be cost effective to defer dismantling if the site is not required for other reasons or if all nuclear power plants on the site will be dismantled in sequence. Dismantling may be undertaken to allow for the reuse of buildings or part of the site if the space is required, or to reduce surveillance and maintenance costs. For smaller facilities immediate total dismantling may be the best solution.

The policies of the country and the licensee with respect to the discounting of future costs will have a major impact on what project work is judged economic to perform in order to lower surveillance costs [6]. Considerations influencing decommissioning options are discussed in other IAEA publications [2, 7]. Detailed planning and approval aspects are covered in Section 4.

2.2. SAFETY

The protection of the public, workforce and environment is a major factor in the organization and management of the overall decommissioning project. Compliance with all legal requirements, both nationally and internationally, is essential. To achieve appropriate standards of safety during the lifetime of the project, the safety documentation is refined and reviewed as required. In this way it can be ensured that the safety documentation correctly and accurately reflects the status of the decommissioning project and provides the necessary demonstration and justification that the safety standards are being applied.

By applying the standards the licensee has access to appropriate health and safety expertise to provide advice, audit and peer review of the safety documentation. Results of monitoring and surveillance need to be properly interpreted and recorded, and the licensee must be able to take preventive and remedial action as needed.

Thus the safety of decommissioning is a proactive task; protection of the public, workers and environment is no less important than during the operational life of the plant.

2.3. WORK APPROACHES

Normally, decommissioning operations begin at sites which already have an operating staff. There are two general approaches that can be followed to accomplish the decommissioning of a facility; they have a substantial effect on project organization. The first approach is for the licensee to perform the decommissioning with in-house resources supplemented by specialist contractors as needed. The second approach is for the licensee to contract with an experienced outside organization to perform the decommissioning activities and then provide general oversight and support services. Examples of either approach are shown in Annexes.

Either approach has advantages and disadvantages. If the licensee performs the decommissioning activity, there is maximum use of the existing staff who have a wealth of hands-on experience. Some of the decommissioning activities are similar to maintenance activities for which procedures are already established. An example is that, during operation of the plant, components are removed and replaced as a normal activity. The use of existing staff provides continuity of local employment. However, some of the more experienced staff may leave because they see their employment ending when decommissioning is completed and will go to other sites where new jobs or long term career prospects are available.

A disadvantage of using former staff to perform the decommissioning activity is that such staff may have difficulties in accepting the cultural changes needed as the plant changes from operational to decommissioning mode, e.g. from routine operations to unique tasks requiring more profound preparation. This may cause such staff to be less efficient than an organization that performs decommissioning activities on a routine basis.

Even in an in-house approach, it is inevitable that at least some contractors will be used on-site. This could imply either one or two specialist contracts (e.g. plasma cutting) or, at the other extreme, using contracts for selected areas of the site. The extent of contractor usage will depend on the policy of staff retention, as well as on cost and availability of suitable contractors.

When an outside contractor is hired to perform the decommissioning activities, the licensee maintains a smaller staff, because of its role as a supervising organization. The outside contractor takes control of major portions of the facility and ensures that the activities are performed safely and in accordance with the regulatory requirements. These experienced contractors are normally more efficient during the decontamination and dismantling activities than the in-house resources. They have performed these activities on a routine basis and are more familiar with the available technologies that can be used to assist them in their efforts, e.g. the decontamination of concrete walls and floors. The contractor can also arrange for any subcontractors that may be needed; their number will probably be smaller than in the case where the licensee performs the decommissioning activities.

When using contractors the licensee still keeps control of the project. In order to maintain this control, the licensee will be required to be in constant contact with the contractor to ensure that all safety and regulatory requirements are met and that the project goals are achieved. It is important that the licensee be familiar with various contracting mechanisms to minimize the risk of cost overruns. Resources and skills needed for the supervising work may be significant.

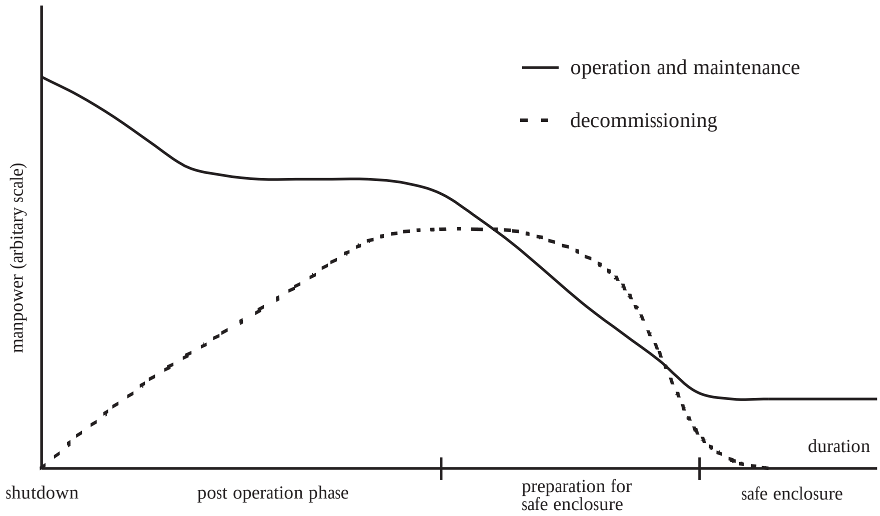

FIG. 1. Typical staff reduction profile during decommissioning.

The licensing regime is based on the premise that the licensee is in day to day control of the facility, processes and activities and that its staff manage the operation of the facility. The licensee is an ‘intelligent customer’ for services provided by contractors. This will still be necessary during periods of care and maintenance and waste storage. Therefore the licensee will need to be able to demonstrate that an adequate organization is and will be in place to discharge these responsibilities until the facility is finally removed from regulatory control and its period of responsibility has ended.

In summary, the licensee must weigh all the options carefully and select the option best suited to fulfil its needs, such as cost–benefit, safety and environmental considerations, as well as social benefits. Multi-attribute analysis is one successful technique to assist the decision making process. One application of this technique is given in Ref. [8]. One example for various possible project management options and the rationale for licensee’s selection is described in Ref. [9]. Specific examples for the use of contractors in UK decommissioning projects are given in Refs [10, 11].

2.4. IMPACT OF DECOMMISSIONING ON STAFFING

There are inevitable constraints on the approach to staffing for decommissioning. For example, in a reactor plant, staff numbers are likely to be held close to operating plant levels until the fuel has been removed and primary circuit decontamination has been completed. The number of people needed will then fall, and the skills needed from the staff will be different from those in operation (Fig. 1). Following these constraints, a range of approaches can be adopted to suit the plant and the social environment in which it is situated.

There are a number of basic points to be addressed and relevant decisions to be made on the following:

- staff reduction profile;
- use of operating staff to undertake decommissioning project tasks;
- sharing key resources among plants;
- policies for choosing what work will be put out to contract.

The staff reduction profile will depend on the work to be done. When such a profile has been established, commitments can be given to staff as to the length of their remaining employment, and progress on staff reduction can be monitored against the planned profile.

Maintaining a high number of operational staff will necessitate that they undertake decommissioning tasks. This will require training in new skills and reorientation of attitudes towards a project completion outlook. The use of an outside contractor to perform a majority of the decommissioning activities may have a negative impact on the local workforce.

In order to encourage a job completion attitude it is enormously helpful if arrangements can be made to warrant future relocation of staff to other plants, projects or similar organizations. One way of approaching this would be to form teams of skilled, experienced personnel who could provide services to other similar plants — effectively as contractors.

It will be important to provide appropriate incentives to staff (and contractors) to work effectively and in a manner that delivers the decommissioning programme safely within the schedule and budget. These incentives may differ from situation to situation, and while seeking to encourage a safe adherence to the decommissioning programme they should encourage staff to seek completion of the work rather than apparently perpetuating their jobs through delay.

Even when using outside contractors, the licensee remains accountable for safety on-site. As such, the licensee is required to have systems in place that will satisfy him that the contractor personnel are suitably qualified and experienced, understand the hazards on the site and are adequately supervised.

In the USA it is estimated [12] that a single unit nuclear power plant undergoing early dismantling has a workforce in the range of 100 to 200 persons. This is approximately one third to one tenth of the number of persons originally employed. During the safe enclosure period the numbers of staff are reduced further to between 20 and 70. For a multi-unit power plant site, each unit in safe enclosure would require a staff level of 20 or fewer by sharing common resources. Following the safe enclosure phase for a single unit facility, staff numbers will increase to 100 to 200, supplemented by contractor personnel to carry out the remaining dismantling activities.

2.5. ORGANIZATION AND MANAGEMENT WHILE PREPARING FOR DECOMMISSIONING

The decommissioning oriented organization in the period well in advance of final shutdown does not need to be large or employed full-time. The expertise required includes aspects such as decommissioning, waste management, cost estimation and licensing. Assistance will be needed from personnel with detailed knowledge of the plant, technical experts and planning system specialists. It will also be vital for this team to learn from experience elsewhere so as to be able to consider the range of options available.

As planning for decommissioning will be important but not necessarily urgent, it may tend to be treated as of lower priority than operational problems; the decommissioning team needs to be protected from such diversions. It will also be

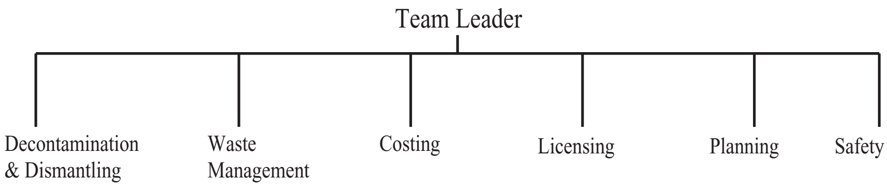

FIG. 2. Decommissioning oriented team during plant operation.

appropriate to supplement the core team with additional personnel from the licensee's organization spending limited periods attached to the team to contribute an essential practical element.

The team reports to the senior management, who is not responsible for day to day operations of the plant. A major benefit of the work of the team is establishing accurate decommissioning costs and risks, which could provide important information for allocating and managing the decommissioning fund. The cost of a small organization such as this should be considered an investment in order to achieve a better managed decommissioning project.

A simple functional structure could be as depicted in Fig. 2.

Once a decision has been made to decommission a facility, and preferably before operation ceases, it is essential to identify and appoint a Decommissioning Project Manager (DPM) having the required skills, qualifications and experience and who has received the necessary authority. The DPM, in consultation with management of the operating organization, should set up a decommissioning project management team to perform the necessary project planning. This will include the development of a decommissioning plan, and its approval where necessary (see Section 4), and control of the resources during the physical decontamination and dismantling activities. As decommissioning proceeds, the decommissioning project management team will expand to include persons with necessary and adequate qualification and experience.

2.6. ORGANIZATION AND MANAGEMENT DURING FACILITY TRANSITION

There are several transition periods associated with any decommissioning project. The two most important are the transition from an operating facility to the

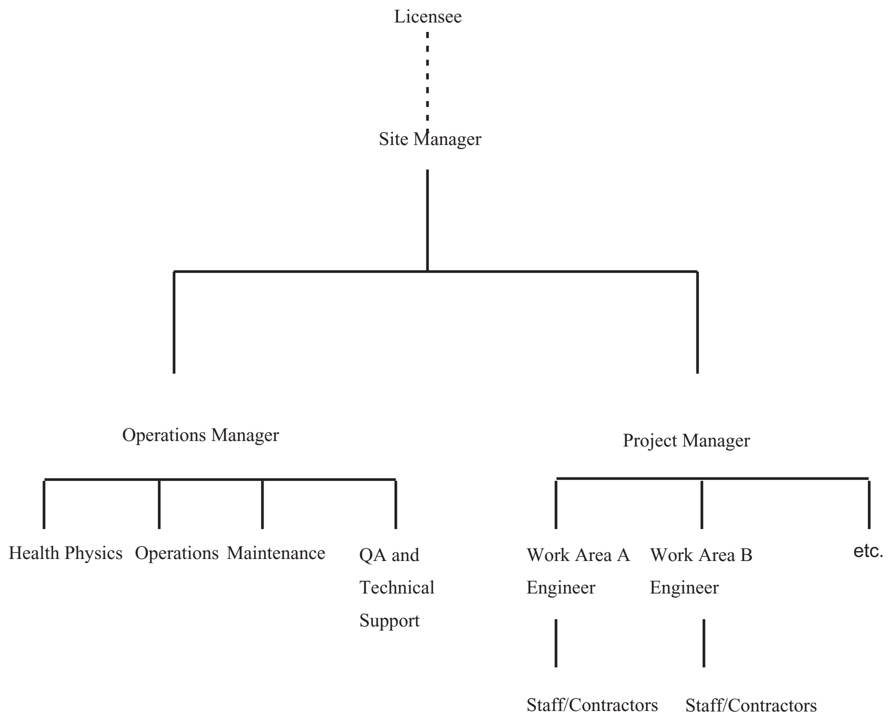

FIG. 3. Organization in the transition phase between operation and decommissioning.

decommissioning period and then from the dismantling period to a post-dismantling period (restricted or unrestricted site release and reuse). The latter is described in Section 2.9. During each transition phase the management structure will need to be adapted accordingly.

The first transition period takes the facility through a deactivation phase after it has been shut down. During this period many of the operationally associated hazards are removed before turning the facility over to the decommissioning team. This may include removal of the spent fuel, draining of systems and removal of waste generated during operation. At all times the management structure will reflect the changing circumstances and continuing responsibility of the licensee for the operation, including decommissioning, of the licensed site. In moving from operation to decommissioning, a cultural change is needed, which is reflected in the appointment of the decommissioning team (Table I; elaboration from Ref. [13] shows the differences between decommissioning and operational states).

The organization at the commencement of decommissioning will inevitably be that which ended the operational phase of the plant's life. In some cases (see

TABLE I. DIFFERENCES BETWEEN DECOMMISSIONING AND OPERATIONAL STATES

Decommissioning	Operations
Temporary design life of structures to assist dismantling	Permanent design of structures for operation
Safety management systems based on decommissioning tasks	Safety management systems on operating nuclear facility
Control based on as-built structures	Control based on drawings
Reduced safety risks but changing situation	Significant safety risks but permanent and routine
Management of changing situation during decommissioning	Management of steady state during operation
Reduced administrative infrastructure	Steady state administration infrastructure
Retraining staff for new activities	Routine training and refresher training
Visible end of employment — refocus their work objective	Permanent employment with routine objectives
New or developing regulations/regulatory requirements	Established and developed regulations for operation

Annex A-11), a new operator takes over for the decommissioning process. Even in these cases, however, it is likely that most of the operating team will be retained for the initial phases of decommissioning. The operating team needs to evolve to suit the job. Part of the planning is to define how the changes in the organization, staffing, contractor usage, usage of mobile teams, etc., will be controlled and when these changes will occur. At least part of the decommissioning project team (Section 2.5) needs to be in place before operation ends.

During the transition period, plant operations, maintenance and provision of emergency arrangements will still be required and may form a separate part of the organization. This part of the organization should be derived from the team that operated the facility. This approach may profit from the accumulated experience and help reduce local employment concerns. It should be noted that the operational team will decrease while the decommissioning team will increase (Fig. 1).

In some cases this organization may continue into the decommissioning period for some time. A reasonable structure for the site management could be of the form depicted in Fig. 3. As one specific example, the evolution of the organizational structure into one solely dedicated to decommissioning is described in Ref. [14].

2.7. ORGANIZATION AND MANAGEMENT FOR ACTIVE PHASES OF DECOMMISSIONING

The management and organization during active phases of decommissioning work, either during immediate or deferred dismantling, is the main focus of this report, and is covered in detail in Sections 3 and 7.

2.8. ORGANIZATION AND MANAGEMENT IN A SAFE ENCLOSURE PHASE

If the decommissioning strategy includes a safe enclosure phase, the following considerations apply:

This phase is characterized by a plant of relative engineering simplicity requiring minimal operation, inspection and maintenance and where the hazards are well defined and controlled, preferably in a state of passive storage.

A minimal organization will be in place during the safe enclosure phase. As the phase is one of stability rather than of change, there are few or even no project staff. It is presumed that sufficient work has been performed to allow relaxation of the need for emergency arrangements of any size. The necessary facility physical protection measures may also be reduced. Finally, off-site environmental monitoring may also be scaled down.

In a specific example [15], the Dresden 1 BWR decommissioning project was part of a multi-plant site that was aimed at safe enclosure. This project required seven permanent staff and was supported by 27 persons from other parts of the site organization providing services such as security and emergency planning.

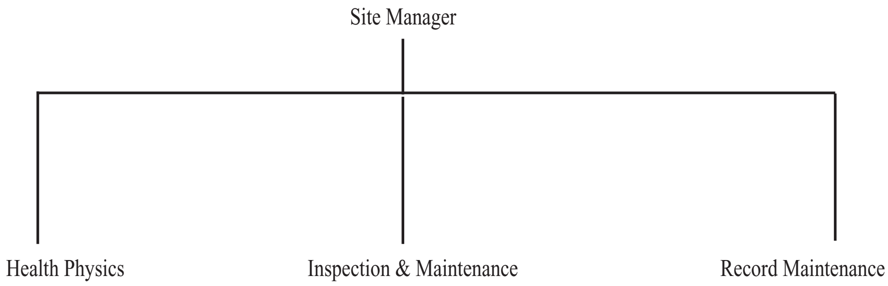

FIG. 4. Organization in a safe enclosure phase.

Construction and maintenance organizations would support the project on an as-needed basis.

The size of the safe enclosure phase organization will depend on the level of dismantling and stabilization/immobilization of wastes that has been undertaken. It may even be appropriate to utilize multi-site mobile teams to perform much of the dismantling work. A simple structure is outlined in Fig. 4.

A significant degree of multi-skilling may reduce staff numbers in this organization. Links to a centralized organization would also reduce the number of staff on-site, particularly for a multi-plant site licensee. The role related to record maintenance is vital to the successful completion of decommissioning.

2.9. ORGANIZATION AND MANAGEMENT FOR THE POST-DISMANTLING AND SITE REMEDIATION PERIOD

The second important transition phase is from the dismantling period to another state which could vary depending on the final end point of the decommissioning project. This end point could be either an authorized reuse for other purposes after identified conditions have been met, or the unrestricted release or clearance of the site. Depending on specific circumstances, authorized release of the site may or may not imply the continued presence of a surveillance unit, whereas clearance implies that all organizational units relevant to decommissioning will disappear. Until the site release criteria have been met it remains a nuclear site with associated controls. The persons responsible for record keeping will then transfer relevant records as required by the regulatory body.

Site remediation may be required to meet authorized reuse or clearance criteria. This could have several activities such as radiological clearance or immobilization, removal of remaining non-radioactive structures and landscaping.

A final report is prepared and presented to the regulatory authorities before the decommissioning team is dispersed towards other duties and while all relevant data, experience and knowledge are still readily available. This report demonstrates that the facility and associated areas have been decommissioned to the state specified in the decommissioning plan or in approved modifications to the plan.

2.10. SPENT FUEL AND WASTE STORAGE ROUTES

Spent fuel or some decommissioning waste may remain stored on-site in an independent facility after decommissioning. Provisions are made by the licensee to assign personnel with sufficient experience to responsibility for the long term care, maintenance, surveillance and safeguards of such storage arrangements.

3. MANAGEMENT FOR ACTIVE PHASES OF DECOMMISSIONING

Section 2 identified the important considerations for decommissioning management. The present section now deals with the detailed consideration of management for the active phases of decommissioning, with the focus on immediate or deferred dismantling. Once the overall decommissioning strategy has been approved, detailed planning can begin. At the start of this planning process, it is necessary to define and implement suitable management structures, as will be discussed in the following subsections.

3.1. ORGANIZATION OF THE MANAGEMENT TEAM

Decommissioning planning addresses such issues as worker and environmental protection, preparation of plans, safety assessment, working procedures, time schedules, training and other technical and administrative aspects. Appropriate additional management, technical and administrative personnel may need to be recruited and assigned responsibility for one or more functions. It is important to select persons who are technically or professionally qualified and have related practical experience. In particular, persons experienced in co-ordination, management and engineering are assigned to the decommissioning project in an early phase so that effective planning can start and be successfully accomplished without undue delays.

For extensive projects such as decommissioning of large nuclear facilities, it is helpful to identify important technical, operational and administrative aspects when defining individual management requirements, even if these aspects are eventually managed by the same personnel.

3.2. THE DECOMMISSIONING MANAGEMENT TEAM

The decommissioning team includes staff having all required skills, qualifications and experience necessary for the decommissioning task, together with a suitable supervisory structure under which it can operate. It will be preferable, particularly in the early stages of the project, to include, in the decommissioning team, persons who were involved in the operation of the facility with knowledge of the plant and its history.

Preference is given to experienced staff, and the team is built up so that all persons are suitably qualified for the tasks they have to perform. Training programmes may be established to ensure that the staff meet the requirements during decommissioning and that records are kept to demonstrate the adequacy of the training. Also, training of the decommissioning team would allow them to perform the decommissioning in accordance with current standards in technology.

The responsibility for managing and implementing the decommissioning project is with the licensee, who appoints a DPM. This is the best way to ensure maximum management commitment, motivation and understanding of requirements for the programme. The DPM would act on behalf of the licensee and would be in charge of the detailed aspects of the planning and management of the decommissioning programme.

The DPM selects and recruits a decommissioning management team and assigns specific responsibilities to each group within the organization. These will be described in Section 7. The DPM will implement the strategy to allocate all or part of the decommissioning programme to external organizations. Basic requirements for a decommissioning team will be the same, irrespective of who carries out the operations.

Possible functional organizational structures for a decommissioning management team required to successfully implement and complete the decommissioning of a facility are shown in Figs 5 and 6. Figure 5 shows a management team where the licensee performs a majority of the decommissioning tasks using in-house resources. Figure 6 shows a management team where the licensee hires an outside organization to perform the majority of the work and the licensee provides supervision and verification of the activities. In either case, the licensee retains overall responsibility for the project and ensures that all regulatory authority requirements are fulfilled. Examples of various decommissioning project management approaches are described in Refs [16–21]. Many details on aspects such as workforce requirements, work plans and procedures, selection of specialty contractors and scheduling for the decommissioning of reference nuclear installations are given in a series of publications by the US Nuclear Regulatory Commission; see, e.g. Refs [22, 23].

3.3. MANAGEMENT OF CHANGE

The period between the announcement to shut down a nuclear plant and the start of decommissioning may present significant challenges to plant management. They need to prepare for new technical and organizational challenges in a climate where there could be pressure to reduce staff numbers. Moreover, increased levels of uncertainty can threaten staff morale and commitment, and the decision to shut down may itself be preceded by periods of rumour and uncertainty. In an industry where security of employment has often been taken for granted, this may be unsettling for plant personnel. The plant management needs to put in place a timely plan to deal with social impact that may occur during plant shutdown (see Annex 9). Psychological distress experienced by the workers during decommissioning of a nuclear plant is described in Refs [24, 25].

The move towards decommissioning can thus be regarded as a process of major organizational change. So far, attention has largely focused on the technical aspects

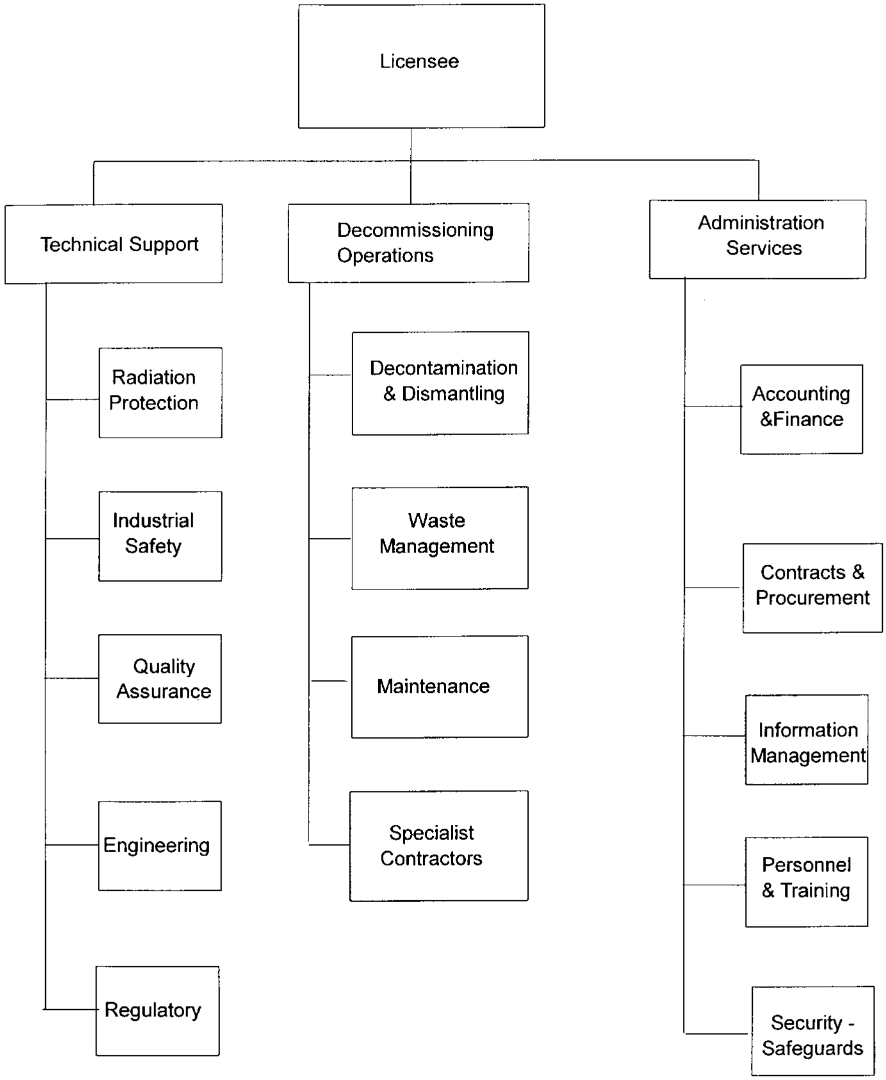

FIG. 5. Licensee performing decommissioning organization.

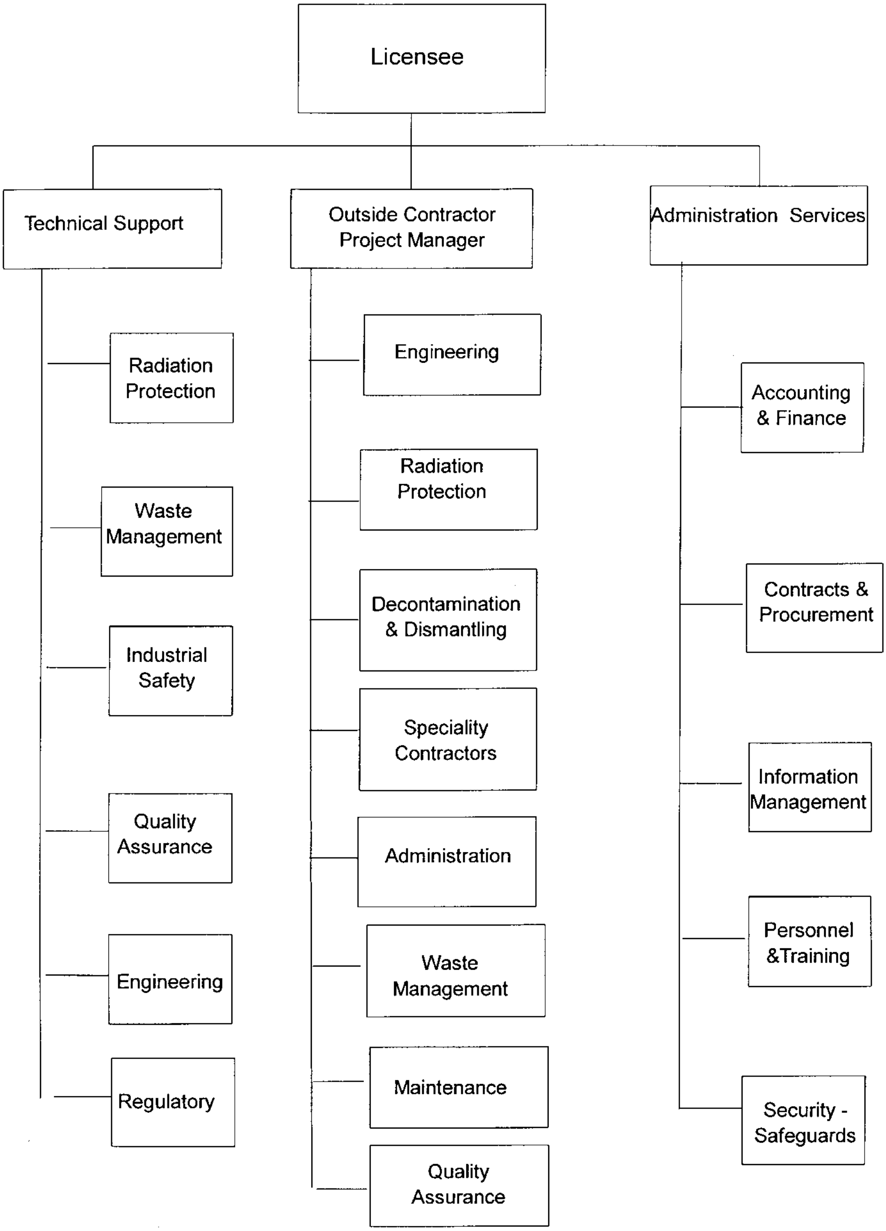

FIG. 6. Licensee with outside contractor performing decommissioning.

of decommissioning, with relatively little attention given to organizational and other human factor issues. Nuclear licensees have embarked on extensive change programmes in recent years to reduce the fixed costs and to enhance the profitability of the companies. This has involved proposals to achieve significant reductions in personnel. These changes need to be carried out in accordance with rigourous and comprehensive management of change arrangements.

One essential point are the licensee’s considerations whether and how any proposed organizational change might impact upon safety. In the context of decommissioning, the organizational challenge is heightened by the changing demands on the workforce. Not all proposed organizational changes have the potential to affect safety. However, where changes involve the loss or redeployment of personnel who have a safety or support role, analysis of the organization’s need for the safety function and the way in which it is carried out, both currently and in the future, is performed. At all times the licensee’s organization remains able to meet projected resource and competence needs.

Decommissioning is often a stage of the plant’s life-cycle where large numbers of external contractors are employed. These groups bring specialist skills to bear which were not called for during normal operation. Contractorization may also be viewed by plant management as a way of making up for any shortfalls in staffing levels which have resulted from the premature release of experienced staff — for example, those who have secured early retirement deals or who have moved to jobs elsewhere which appear to offer a more secure future. Contractorization is becoming a fact of life and can bring benefits. However, it is vital that the licensee retains sufficient competent personnel to understand, own and use the plant safety case, and to act as ‘intelligent customer’ for work by contractors (Section 2.3). This is especially important during decommissioning. Older plants may not have a comprehensive set of drawings and procedures, so that many historical aspects of plant design and operation which need to be accessed during decommissioning are vested in individuals rather than in paper work. These persons are retained so long as their knowledge and experience can plausibly be required, and it is also preferable that this experience is documented in a form available for use by other personnel.

4. DECOMMISSIONING PLANNING AND APPROVAL

4.1. GENERAL

Successful decommissioning depends on careful and organized planning including clear identification of the objectives of the decommissioning process. The end states are derived from the objectives of the organization charged with completing the work and are in compliance with requirements by the regulatory body and other competent authorities. Moreover, the agreed upon end states will be readily verifiable and can be independently measured and reported in a quantitative way.

Once a strategy has been developed, the decommissioning plan is prepared for each nuclear facility. The extent of such plans and their content and degree of detail required may be different, depending on the complexity and hazard potential of the nuclear facility and on national regulations. Typical contents of a final decommissioning plan can be found in Refs [3, 4, 26] and are indicated in Table II.

Planning to allocate adequate financial resources to ensure the decommissioning of a nuclear facility is made preferably at the early stages of the plant's life-cycle. Especially in the case of deferred decommissioning, where there may be long safe enclosure periods, these financial provisions are reviewed periodically and adjusted, if necessary, to allow for inflation and other factors such as technological advances, waste disposal costs and regulatory changes. Responsibility for this review may reside with the licensee, the regulatory body or other parties, depending on the national legal framework.

A radiological characterization and material inventory assessment is carried out for the facility at the early stages of decommissioning planning. This provides support for a number of activities including waste management, decontamination and decommissioning methodologies, and safety and environmental assessments.

A safety and environmental impact assessment forms an integral part of the decommissioning plan. The licensee is responsible for preparing this assessment and submitting it for review by the regulatory body as required. The safety and environmental impact assessment should be commensurate with the complexity and the associated decommissioning hazard potential. Guidance on the preparation of a safety assessment is provided in Ref. [27].

4.2. PREPARATION OF THE DECOMMISSIONING PLAN

When the timing of the final shutdown of a nuclear facility is known, the licensee should initiate detailed studies and finalize proposals for decommissioning. Following this, the licensee should submit an application containing the decommissioning plan for review and approval by the regulatory body. The decommissioning plan may require amendments or further refinements as decommissioning proceeds and may require further regulatory involvement.

If the selected decommissioning option results in phased decommissioning — with significant periods of time between phases —, the level of detail of the items in Table II may only be required for the next immediate phase being executed. As

TABLE II. EXAMPLE OF CONTENTS OF A DECOMMISSIONONG PLAN

Section	Contents
1. Introduction	Objectives, scope, goals to be achieved
2. Facility description	Physical description of the site and the facility and its operational history Radioactive and toxic material inventory
3. Decommissioning strategy	Objectives, decommissioning alternatives Selection and justification of the preferred option
4. Project management	Resources Organization and responsibilities Review and monitoring arrangements Training and qualification Reporting and records Risk managment
5. Decommissioning activities	Decontamination and dismantling activities Waste management Maintenance programmes
6. Safety assessment	Dose prediction for tasks, demonstration of ALARA for tasks Risk and uncertainty analyses Operating rules and instructions
7. Environmental impact assessment	Demonstration of compliance with environmental standards and criteria
8. Quality assurance programme	Setting up a QA (quality assurance)/QC (quality control) programme Verification of compliance with established QA requirements
9. Radiation protection and safety programme	Radiation monitoring and protection systems Physical security and materials control Emergency arrangements Management of safety Justification of safety for workers, general population and environment
10. Continued surveillance and maintenance	Development of surveillance and maintenance programmes
11. Final radiation survey	Demonstration of compliance with the cleanup criteria
12. Costs	Cost estimate Provision of funds

a result of executing an individual phase of the decommissioning, some modification to the planning for subsequent phases may need to be done. In such cases, subsequent sections of the decommissioning plan may require updating and reviewing.

4.3. PROJECT RISK MANAGEMENT

Experience has shown that large projects may fail to meet their objectives, in terms of time, cost and quality. This is a particular concern for projects where there is limited previous experience, the technology has not fully matured and there are risks associated with technical performance. This could be the case for nuclear facility decommissioning and environmental restoration projects which may have uncertainties. Project failure may often be identified as resulting from events which had not been anticipated during project planning but which might, by hindsight, have been accommodated had they been identified at the outset.

Accordingly, formal project risk management (PRM) techniques have been developed to address these problems [28]. Such techniques adopt the basic approach of attempting to identify all potential hazards before they are realized and implementing actions to prevent their realization or to limit their consequences. The process includes commercial and managerial as well as technical risks. A further key role of formal PRM is the allocation of ownership of risk, i.e. the identification of the party who is responsible for a given risk and who will carry responsibility for its management. Risk allowance as part of contract negotiation can help prevent disputes later during project implementation and provide justification for any provision for risk to be made in pricing or programme.

Typically, implementation of formal PRM will involve the following key steps:

- development of PRM strategy, to identify the objectives for PRM implementation in the given context and define the requirements for risk assessment, risk analysis and risk management planning over the project life-cycle;
- risk assessment, a workshop to identify risks to project success and potential consequences (cost and programme). Also to identify possible actions that might be adopted to manage them. The logical process and implementation mechanisms of project risk assessment are described in Fig. 7;
- risk analysis, to quantify the overall impact of identified risks on project cost and programme and to evaluate the effectiveness of potential responses;
- risk management, to select the preferred responses to addressing the identified risks and to allocate residual risks most appropriately among the parties involved. This is an ongoing process throughout the project.

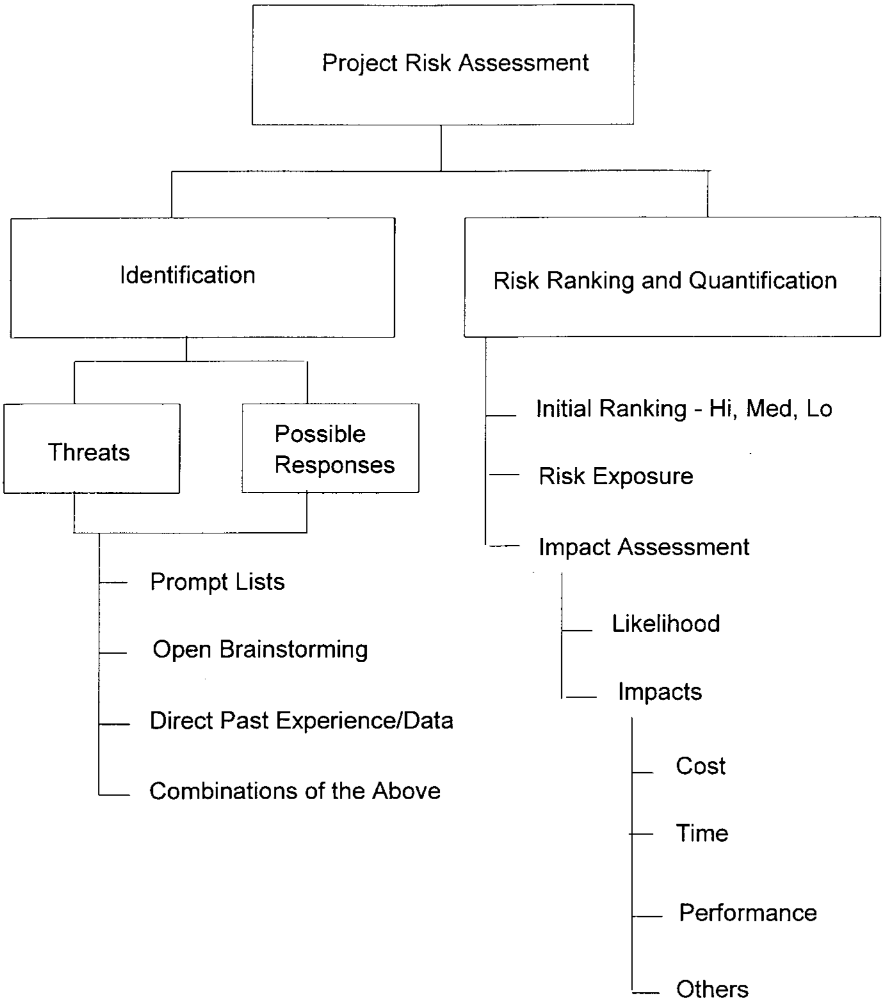

FIG. 7. Summary of elements of project risk assessment and analysis.

A specific application of PRM is described in Ref. [10]. Different contract models to address the balance of risk and related project management issues are described in Ref. [29].

4.4. REGULATORY APPROVAL

To ensure compliance with national, regional and local regulations, standards and laws, it is important that the licensee, before or during the planning stage, identify all relevant legislation likely to be applied in the decommissioning programme. However, in many Member States, specific requirements for decommissioning have yet to be developed or finalized. In the absence of such requirements, decommissioning activities could be undertaken on a case by case basis under existing regulations, for example, the arrangements for carrying out modifications on operational facilities. In such cases it would be convenient for the licensee to be in regular consultation with the regulatory body throughout the development and implementation of the decommissioning programme.

The regulatory body or other competent authorities may review:

- decommissioning strategy
- decommissioning plans and programmes
- procedures employed during the decommissioning process, in particular clearance of materials/wastes
- surveillance and inspection
- safety assessments
- funding provisions.

Times-cales for review of the decommissioning tasks by the regulatory authorities should not be underestimated. These can have a significant impact on the whole project time-scales and, consequently, the costs (see Annex A–6).

The regulatory body will verify that the final condition at the facility meets the approved objectives established at the beginning of the project. Further guidance on these issues is given in Ref. [4].

4.5. WORK PACKAGES AND PROCEDURES

While the decommissioning plan and safety and environmental assessment are being reviewed by regulatory bodies, detailed planning and engineering can begin. As detailed data are made available from the radioactive inventory of the nuclear facility and the site characterization programme, decisions on the handling of components, structures and soil can be made.

Multiple levels of planning documents are usually prepared; one example will be described below. A hierarchical work breakdown structure is developed which divides the work into manageable packages, which identify what is to be done and how, and addresses the basic safety considerations of the activity. Another level of documents are the detailed work procedures.

The work packages identify the purpose and the description of the task, applicable criteria and the activity sequence of events. The criteria include engineering and technical requirements; health, safety and environmental protection requirements; and reference to applicable standards. Work packages refer to other documents such as Radiological Health and Safety Manual, Waste Management Manual, Security Plan, Quality Assurance Programme, Fire Protection Programme, etc.

The detailed work procedures identify the step-by-step instructions to perform each task, the required equipment and associated operating parameters (cutting speeds, gas pressures, power requirements, etc.), safety precautions and disposal methods, as applicable. Detailed work procedures are general or specific work procedures. General work procedures are used for repetitive activities such as construction of contamination control tents, rigging and lifting, pipe cutting methods and maintenance of filtered equipment (HEPA vacuum cleaners, ventilation units, liquid filtration systems, etc.). Specific work procedures apply only to unique tasks such as core dismantling activities or asbestos removal, where general work procedures cannot be fully applied.

As the work packages and detailed work procedures are developed, the baseline cost estimate, schedule and personnel radiological exposure estimates are refined. These can then become the guidelines against which the project performance is measured.

The decommissioning plan will identify and justify the decommissioning work activities. However, before work commences, work packages are developed for these activities and analysed in sufficient detail to allow the decommissioning team to execute the work with a clear understanding and without the need for further significant explanation. The packages are arranged into interrelated groups, and a schedule of activities usually represented by a bar or Gantt chart would be prepared. Formal project management techniques are applied to the creation and management of work packages. A critical path network, i.e. a diagram indicating the sequences and interdependences of the various work packages, may be used. The work packages are planned as soon as possible because such planning greatly assists in the development of detailed cost estimates and the identification of specialist support and equipment that may be needed. Without this level of planning it is difficult to schedule the decommissioning of a large nuclear facility with any degree of certainty.

Procedures for allocating work packages to the decommissioning team are developed. Work monitoring arrangements are set up so that the project management schedule can be re-evaluated when unexpected circumstances arise. The DPM holds periodic formal review meetings with all supervisors and safety staff to assess work done, current status of the facility and future tasks. Each member of the team would then be aware of what is to be done next in other parts of the programme and in other related activities.

From the formal project meeting, progress reports including revised cost estimates are prepared periodically and are presented to the regulatory body, licensee and other authorities, as required, including the organization providing the funds [1].

Two approaches to the specification of work packages in Germany are described in Refs [30, 31]. These references describe, inter alia, formation of working groups for each work package and their further subdivision into working steps.

5. QUALITY ASSURANCE

5.1. OVERVIEW

Any activity having an impact on the health and safety of workers, the public or the environment, or affecting the success of the project, is covered by a quality assurance (QA) programme including management and organizational aspects. For such activities it is necessary to have written procedures, documentation, control guidance on the selective applications of QA procedures, and accurate information and techniques to verify compliance with QA procedures [32].

A QA programme will continue to be needed for all activities to be controlled. It is generally adapted from that used during operation, concentrating on those aspects associated with the management of change. As such, it needs to evolve as organization and manning evolve throughout the decommissioning programme. A number of phases can be seen in the programme during decommissioning. To give an example: when a reactor is being defuelled or the primary circuit is decontaminated, hazards and activities are not dissimilar to those experienced during operation. During dismantling and demolition the management of change predominates, and the QA programme needs to reflect that. At the end of the period of change, the site may go into surveillance with low staff numbers. At this stage, a very simple QA programme is all that is necessary.

It is important to recognize that the reduction in costs, staff and administration generally can be achieved by a progressive simplification of the QA programme as decommissioning proceeds. This originates ultimately from an adaptation of the safety assessment case, because of lower nuclear hazards as work progresses. This allows a reduction in rules for operating plant systems, maintenance requirements and their implementing documents. Plant items can be released from service and decommissioned. The overall effect is to reduce the need for staff. The QA programme is designed to control this change process so that each step occurs in a co-ordinated way, and the QA programme itself needs to evolve to suit the changing circumstances.

In performing the planning for the decommissioning project, it should be recognized that health and safety are not always affected to the same degree for every facility, and a graded approach to QA can be developed to ensure an adequate level of quality for factors such as maintenance and equipment reliability. Less stringent controls could be utilized for functions not affecting safety but must be justified.

The QA programme is initiated before the decommissioning activities commence. A summary of the QA programme is incorporated in the decommissioning plan and includes, as a minimum, the basic elements to be discussed in the following subsections.

5.2. CONTROL OF MODIFICATIONS TO THE PLANT

Procedures for carrying out modifications to the plant would have existed for the operational phase of the facility. These can be utilized, simplified where possible and adapted for the decommissioning phase.

5.3. RADIATION PROTECTION AND ENVIRONMENTAL SAFETY CONTROL

The radiation protection specialist will assess the procedures and instrumentation that will be used for the various types of radiological and environmental survey to ensure appropriateness. Decommissioning procedures are reviewed to ensure that the appropriate data for radiological assessments are being used (Section 5.6). Criteria for collection and analysis of radiological samples during the decommissioning process are reviewed by the radiation protection specialist. Independent analysis may be performed to ensure that results are accurate and reproducible.

5.4. CONTROL OF OUTSIDE CONTRACTED SERVICES

Contractors are used for a wide variety of tasks. A common use is for a self-contained specific project. In such cases the licensee still maintains the capability of defining, monitoring and supervising the work (Section 2.3). However, contractors may also be employed to provide services such as health physics expertise or maintenance. These contractors need careful management by the licensee to ensure that the licensee retains control of intellectual property and assets remain available to the licensee. If the contractor is replaced, a proper handover is arranged so that the new contractor's staff are trained to be suitably qualified and experienced when they take over.

The licensee has the responsibility for ensuring that contractors achieve the required quality, although contractors are responsible for the quality of their own work. Once their detailed work plan is approved by the licensee, this assurance is achieved by a programme of surveillance and inspections. Among other aspects, supervision of a turnkey contract is described in Ref. [33].

5.5. SURVEILLANCE AND INSPECTIONS

Procedures of surveillance and inspections are an integral part of quality assurance. In facilities where a great majority of the decommissioning work is carried out by external contractors, surveillance should be documented to show what was inspected, by whom, the results of the surveillance, and the corrective action if there was any non-conformance. Internal quality audits may be performed to assure that all parts of the programme are working properly. Other inspection activities may include calibration of measuring equipment, verification of characterization, packaging and disposal of radioactive waste, or inspections of quality of materials and equipment purchased. The opportunity exists, during early surveillance and inspection work, to assess the as-built condition of the facility against the existing drawings and documentation. This assessment could be carried out when modifications to the facility are required.

5.6. MANAGEMENT OF INFORMATION

An important element to emphasize in the development of a QA programme for decommissioning is the collection and retention of records and information relevant to the facility. In the case of deferred dismantling of a facility, the maintenance of accurate and complete information relating to the locations, configurations, quantities, and types of radioactivity and other hazards remaining at the facility is vital to the successful and safe execution of any surveillance and maintenance and of subsequent final decommissioning activities. Furthermore, for clearance purposes it is important to document that all radioactive materials and other hazards present at the beginning of decommissioning have been accounted for and their ultimate destination has been confirmed. It is also important to have documentary evidence that all cleared waste and materials and the site itself have been properly monitored before being released from regulatory control.

QA will verify the procedures and equipment which will be used to acquire, record and manage important information related to all aspects of the programme and to ensure retrievability of documentation. QA will verify that the records required at the end of decommissioning contain information on all operations described in the plan, including items such as:

- records of waste or materials — origin, processing, characterization, transport arrangements and destination;
- details of the licence, other authorization documents and all criteria and standards used during decommissioning;
- details of the equipment and procedures used;
- all recommendations, audit reports, corrective actions, agreements, endorsements and consents in respect of any stage of the decommissioning programme;
- all safety assessment documentation;
- any independent reviews prepared in accordance with national requirements;
- all references cited in the safety documentation, or a statement as to where the referenced document can be located;

- drawings used during decommissioning activities; and
- details of the final radiological survey for release of the site.

Some operational records will need to be retained during and after the decommissioning period for:

- legislative requirements
- aiding further decommissioning activities
- possible litigation in the future.

The characterization of records generally includes the following:

(1) requirement for the record (e.g. which legislation)
(2) record type (i.e. what is recorded)
(3) retention period
(4) producer of record
(5) responsible holder of record
(6) storage medium
(7) storage location(s).

The choice of a suitable storage medium is an important consideration. Four media are primarily in use today:

(i) paper
(ii) microfilm
(iii) editable electronic media (magnetic disks/tapes)
(iv) read-only electronic (CD-ROM image).

Table III summarizes the advantages and disadvantages of each medium.

In terms of costs, reading the table from left to right, we see that the trend is to higher capital costs and lower maintenance costs. For an older plant the solution will probably be a mixture of media to suit the record type, in all cases with adequate backup facilities.

If any record keeping medium is developed, establishing its legality is essential before the original record is destroyed.

5.7. AUDITS

Periodic safety audits of decommissioning activities are performed and documented to evaluate effectiveness of worker training, surveillance equipment operability and adequacy, management control, safety controls, compliance with ALARA,

TABLE III. ADVANTAGES AND DISADVANTAGES OF RECORD-KEEPING MEDIA

Medium	Paper	Microfilm	Editable electronic	Read-only electronic
Advantages	Readily available	Compact	Can be updated	Compact
	Storage understood	Standard technology	Compact	Accessible
				Easy storage
	Legally acceptable	Legally acceptable		
Disadvantages	Bulky	Awkward to access	Need to keep hardware and software available	Need to keep hardware and software available
	Requires controlled storage conditions	Requires controlled storage conditions	Only useful for new records	Legality unclear
			Corruptible	
			Legality unclear	

emergency programme, documentation systems and exposure assessments. Audits also review and evaluate for conformance to established specifications and procedure requirements.

To review and track safety audit results, a safety review structure is established which would implement an audit programme and control the application of radiation protection and environmental safety policies during decommissioning. All necessary procedure requirements are established at the very beginning of the planning stage and should be appropriately documented. In one specific case, auditing is used as a means to encourage safe behaviour (and conditions) and to discourage unsafe behaviour [34].

5.8. MANAGEMENT, ASSESSMENT AND REPORTING OF INCIDENTS AND EVENTS

Procedures are in place and agreed with the regulatory body and other competent authorities for the management, assessment and reporting of incidents and events. This would include the reporting of incidents under the INES system [35].

6. WASTE MANAGEMENT

Waste management is an important part of the decommissioning process. Relevant management and organizational structures will be discussed in the following subsections.

6.1. WASTE MANAGEMENT STRATEGY

Waste management strategy is a part of the overall decommissioning plan. This is to ensure that the generation, conditioning and disposal of wastes from the decommissioning process is conducted in a manner consistent with the project, waste minimization and the acceptance criteria. This strategy is based on national and regional waste management regulations and also takes into account government policy. It generally includes items such as:

- an estimate of the sources and types of waste, their physical and chemical characteristics, and the volume of each waste category, including the rate at which waste will be generated (Section 4.1);
- criteria for the restricted/unrestricted reuse or recycling of equipment or materials from decommissioning;
- criteria for segregating waste into various categories;
- the plans and procedures for handling, treating, conditioning, storing and disposing of each category of radioactive, non-radioactive and hazardous wastes from decommissioning;
- procedures for monitoring and recording radioactivity, including monitoring cleared wastes before unrestricted release as well as taking and analysing samples;
- requirements for packaging and package design for transport and disposal;
- identification of adequate storage and disposal routes and sites (in some cases the waste streams may not have readily available routes for conditioning, treatment, storage and/or disposal or reuse);
- a safety assessment of the waste management strategy.

This waste management strategy includes aspects such as possible reuse and minimization of waste, including secondary waste, through the use of waste minimization and volume reduction techniques. Techniques that may be employed include, among others, decontamination, size reduction, process optimization and volume reduction, e.g. evaporation of liquids or compaction of solids. It is expected that several different waste streams will be generated during the course of decommissioning; these may need to be considered on a case by case basis in the development, modification and application of appropriate waste management techniques.

The waste management strategy addresses how the applicable waste acceptance criteria for disposal will be met. If wastes from restricted areas are to be disposed of by landfill or similar methods, the means of demonstrating that the release criteria are met are specified and documented. If some wastes are to be released for unrestricted use, special monitoring and analysis procedures capable of measuring the very low levels of radioactivity that are specified for unrestricted release are of concern. For this purpose an area with low background radiation may be required so that the necessary measurement can be made, and/or extensive sampling and counting in the laboratory can be implemented.

6.2. WASTE MANAGEMENT ARRANGEMENTS

Decommissioning operations which produce radioactive wastes can only be initiated when well defined waste management arrangements have been made. In many situations the final disposal of waste will be transferred to an organization different from the facility licensee. The conditioning, packaging and recording arrangements are formally agreed with the repository organization before the recovery and conditioning of any waste is commenced.

In addition, many facilities generate both radioactive and other hazardous wastes. The development of a plan for hazardous material characterization will provide an important insight into the impact of these materials on treatment, conditioning, packaging, storage and final disposal.

Procedures, processes and systems to be used for handling, treatment, conditioning, storage and disposal of radioactive wastes are defined.

If radioactive wastes are to be temporarily stored on-site, the quantities of wastes, the expected length of storage, the location of storage areas, radiation levels at access points and the manner in which control will be maintained are defined.

The methods of managing of radioactive wastes from decommissioning will, in general, be similar to those used in other parts of the nuclear industry during operation, maintenance and refurbishment of facilities. However, the volumes and characterization of the waste streams may require some modifications to the methods used.

7. RESPONSIBILITIES AND QUALIFICATIONS

Depending on the regulatory system, a specific licence or authorization, different from the facility operating licence, may be required to undertake any decommissioning activity. In some cases, during the decommissioning period, the facility may be operated by a new licensee separate from the former licensee but who nevertheless satisfies the requirements and is deemed competent to hold a licence.

Although the licensee in charge at any point in time is legally responsible for carrying out the decommissioning activities, including funding, in accordance with the regulatory requirements, the financial liability or funding sources for decommissioning may be held by a third party(ies). This is specially true for government owned facilities. The licensee will then ensure that adequate funds are available and committed before commencing any decommissioning activity. The following subsections offer one way of allocating responsibilities for the actual decommissioning work.

7.1. LICENSEE

The licensee is responsible for all decommissioning activities and directs the DPM to ensure the safety and cost effectiveness of the project. The licensee provides the necessary liaison with the regulatory authority and the public and makes available adequate funds to ensure that decommissioning is completed. The licensee defines the limits of the DPM's delegated powers which may vary between organizations.

7.2. DECOMMISSIONING PROJECT MANAGER

The DPM leads the project management group and is directly responsible to the licensee of the facility. This function co-ordinates and supervises all activities during the whole period of decommissioning or until the desired stage of decommissioning is achieved. The DPM directs the decommissioning team to ensure safety and cost effectiveness of the project. The DPM is responsible for controlling the expenditure of funds and ensures that the decommissioning can be completed within the available budget. The DPM is also responsible for managing staff numbers, skills and organization to meet the objectives of the decommissioning project.

Typically, the DPM has previous project management experience in a radiological environment. It would be preferable that this individual has either previous decommissioning, large scale maintenance or refurbishment experience.

Of major importance during the whole decommissioning period is for this DPM to monitor, control and evaluate expenditure and activity progress versus budgetary estimations and planned timescale. This will involve generation and updating of expenditure profiles and percentage completed activity diagrams, together with data on key project milestones, and the extent to which milestones have been achieved or progress has been delayed. This information is essential for the overall management of the project. This will enable an optimal management of funds or identify a lack of funding and a need for re-evaluation of the further decommissioning activities. Furthermore, the evaluation of the real cost of performed decommissioning activities will enable to redefine the cost of work packages, which can be integrated into the cost re-evaluation of the resulting decommissioning activities. Finally, achievement of technical and safety milestones will also be of particular interest to the regulatory body and the fund manager.

A key function of the DPM will be the monitoring of progress by meetings, regular reports, performance statistics, post-task and post-project reviews and by benchmarking performance against similar projects where available. It is only by monitoring and measuring performance that it is likely that deficiencies will be identified and improvements can be obtained.

Some suggested key performance indicators include:

Safety:	Accident frequency rate per 100 000 h worked Radiation doses compared to ALARA assessments and legal limits Site reportable events
Project:	Project lifetime decommissioning costs (cash and discounted) Waste volume quantities Surveillance costs Site infrastructure costs Estimated cost of subprojects to completion versus sanctioned sums Milestones achieved.

7.3. TECHNICAL SUPPORT

The technical support will include staff experienced in technical topics such as radiation protection, industrial safety, quality assurance and engineering. These topics will be discussed in the following subsections.

7.3.1. Radiation protection

As part of the decommissioning plan, a radiological protection programme is prepared and implemented to ensure safety of workers and the general public as well as protection of the environment. Such a programme is intended to optimize the working methods according to the ALARA principle. It typically includes on-site, off-site and personal monitoring, recordkeeping of dosimetric data and assessment of the results obtained. The involvement of skilled personnel and the use of adequate equipment for dosimetry, personnel protection, radiation and contamination surveys, and clearance measurements for materials/waste will be crucial to the safe decommissioning of the facility.

A radiation protection specialist will be responsible for ensuring compliance with radiation work procedures. This person advises or directs the activities of the health physics technicians, who monitor all decommissioning activities and measure and record radiological information. The radiation protection specialist maintains the occupational exposure records and develops and implements the radiological emergency preparedness plan.

The radiation protection specialist is the advisor to the project personnel on all matters relating to radiation protection. Experience with decommissioning activities is desirable. Inclusion of operational health physics staff from the plant in the team could be of great advantage, especially in old facilities where operational records may not be up to date. As one example, the radiation protection organization and staffing in charge of Yankee NPP's Component Removal Project is described in Ref. [36].

7.3.2. Industrial safety

A general industrial safety programme must be prepared and implemented to ensure the safety and health of the workers and protection of the environment from non-radiological hazards. This is constructed to comply with all applicable health and safety legislation. Such a programme includes approved safety practices, monitoring of worker areas and identification or specification of personnel protective equipment.

An industrial safety specialist will be responsible for developing and implementing the industrial safety policy. The specialist advises the project personnel on all industrial safety matters (e.g. fire, toxic substances, noise, dust, etc.) and develops and implements the non-radiological emergency preparedness programmes. Consideration is normally given to the provision of medical surveillance for the decommissioning staff.

7.3.3. Quality assurance

A quality assurance (QA) programme is established at the earliest practical time during the decommissioning planning, consistent with the schedule of accomplishing the proposed activities. The programme is designed to provide a flexible degree of monitoring of ongoing work, based on detailed planning, inspection and auditing, and operated with a minimum of personnel involved.

A member of the decommissioning team is assigned the QA representative for the project and utilizes the QA department of the organization. To ensure the independence of the QA department, this group has direct access to the licensee, independent of the decommissioning team. The QA representative maintains audit and job records and verifies that established procedures are followed with support from the QA department of the organization. More details on QA during decommissioning are given in Section 5.

7.3.4. Engineering

The engineering group is responsible for the detailed characterization of the facility and its systems and components, including current status and any historical information. The engineering group is also responsible for developing detailed work procedures and specifications for the scheduled tasks. They will also identify the need for special equipment and tooling and evaluate the technical side of the decommissioning subcontracting. The engineering group will help establish the plans and detailed task schedule, track progress and identify any potential concerns. It will incorporate specific radiological data provided by the radiation protection team. The engineering group and the radiation protection team will work closely together as required during the decommissioning project.

The required engineering expertise can be drawn from the existing operating facility itself, supplemented by additional specialist resources as necessary. The group typically includes at least a civil engineer, an electrical engineer and a mechanical engineer.

7.3.5. Regulatory control

This group provides guidance to the decommissioning team for compliance with regulatory requirements during the decommissioning process. In this way compliance with licence requirements can be demonstrated. For this purpose administrative and technical resources are vital.

7.4. DECOMMISSIONING OPERATIONS

Personnel within the decommissioning operations group are drawn from the plant operations team wherever possible to gain maximum benefit from the experience gathered during the operation of the facility. In an organization performing decommissioning in-house, this group provides the workforce that will perform a majority of the decommissioning activities. Typical functions of this group will be described in the following subsections.

7.4.1. Decontamination and dismantling

The decontamination and dismantling group is responsible for performing the main actions associated with decommissioning operations in accordance with agreed procedures. This group dismantles or removes components from their design locations and packages the material for further processing. They may decontaminate or segregate components or structures to assist in dose reduction or to meet clearance criteria. This group may perform volume reduction at the removal site if this is more cost effective than having a centralized waste reduction facility operated by the waste management group. This group will contain the necessary skills and trades to carry out these tasks.

7.4.2. Waste management

The waste management group is responsible for ensuring that requirements and procedures developed for the handling, treatment, conditioning, storage and transport of the generated waste are met. This group will ensure that the waste acceptance criteria are met, in particular, before shipment of the waste to the disposal site. They may be responsible for volume reduction if a centralized waste reduction facility is established, and in developing a waste minimization programme. This group, together with the radiation protection and industrial safety groups, will characterize the waste and identify the various waste streams including verification and compliance with clearance criteria. The waste management group will arrange for transport and disposal of the waste and prepare the necessary documentation. More details are given in Section 6.

7.4.3. Maintenance

Before decommissioning commences, a routine inspection and maintenance programme is implemented for all safety related systems and components that are required to support the decommissioning activities (e.g., ventilation, fire control, water, filters, radiation monitors, specified pumps, motors, fans). These systems and components will have to be maintained throughout the decommissioning project to comply with safety requirements. This group is responsible for providing inspections of this equipment and keeping records of maintenance performed, defects found and remedial actions taken. The group may consist of electricians, plumbers and other specialists familiar with the various support systems.

7.4.4. Specialist contractors

During decommissioning, specialist contractors may be employed to provide services to the facility’s decommissioning team. In the case of large nuclear installations, the list of specialized contractors may include, among others, transport contractors and remotely operated equipment specialists. Use of contractors may increase the overall cost effectiveness of the decommissioning project by improving the efficiency of specialist operations and therefore reducing the need for specialist staff training.

7.5. ADMINISTRATION SERVICES

The administrative aspects of the project are the responsibility of the DPM, but expertise may be provided by specialists such as accountants, contract and procurement agents, information management, personnel and training officers, lawyers and security. Key aspects of administrative management are described below.

7.5.1. Accounting and finance

A financial case will have to be made for the selected decommissioning option, which will include a detailed cost estimate and the rate and time-scale of expenditures. The detailed cost estimate would be done as a joint activity between the technical support staff, who define the work packages and resources required, and the administrative staff or external specialist contractor, who have the financial cost estimating expertise. After approval of the estimate, the licensee will have to agree on an expenditure budget for the decommissioning programme with the organization that is providing the funds. This consists, as a minimum, of a summary of decommissioning activities, the agreed expenditure limit for each activity and the point of time when funds are required.

For a decommissioning project on a multi-plant site, where other operations are continuing, the licensee may be able to utilize existing accounting services for recording and monitoring expenditures. For a single plant site it may be appropriate to employ accounting services.

7.5.2. Contracts and procurement

Contracts and procurement functions will be required to assist the DPM in negotiating contracts for specialty contractors, procurement of special installations and equipment, special services and procurement of consumables. However, it will be a responsibility of the DPM to ensure that any contracted work is done in a timely, economic and safe manner. Before contracts are awarded, the qualifications and experience of the contractor’s staff and the quality assurance procedures operated by the contractor are verified. The size of the procurement and contracts group will depend on who is going to perform the majority of the decontamination and dismantling activities, the in-house decommissioning team or the contractor(s).

For decommissioning projects the procurement of large quantities of consumable items, such as personnel protective equipment, is a possibly underestimated issue. Because of the quantity and diversity of this equipment, an extra burden may be placed on the contracting organization. The process of resupplying these items is reviewed periodically to ensure continued best value. In addition, the technical support staff ensures that special equipment (e.g. instrumentation, decontamination units, transport containers, dismantling tools) has been identified in advance and procured in time to suit the planned sequence of decommissioning activities.

7.5.3. Information management

A system is set up using QA requirements by which the data, operational records and reports are regularly received, registered, controlled and stored. The regulations may require that all, or some, of these records be kept after decommissioning has been completed. For all decommissioning projects, a technical data management group is in place; its purpose is to control the large amount of technical data that will be generated by the decommissioning team during the decommissioning process (see Appendix 1). For example, large amounts of technical data may be collected, including survey data which could amount to many thousands of records. Once collected, all these data must be analysed, retained and placed into a comprehensible and retrievable form.

7.5.4. Personnel and training

The services of an experienced personnel manager and staff are essential to look after all personnel problems associated with the decommissioning staffing issues which may arise with operational staff after the shutdown of the facility. Principal aspects are likely to be substantial changes in the workforce involving staff reductions and/or redeployments, and staff counselling related to some uncertainty arising from the closure of the plant or finalization of various stages of the decommissioning programme.

It may be difficult to maintain all necessary skills as the workforce changes. This will require a commitment to the retraining of staff, including contractors, in order to meet the different challenges as work progresses. The nature of the work may push for a reduction from the numbers of staff originally employed at the plant. The requirements to maintain a site memory, that is people with immediate personal knowledge of the plant and its history, may tend to require a potentially higher retention of operating phase personnel. Emergency arrangements may also provide a similar pressure for staff retention.

The pressure to reduce costs by reducing staff will tend to promote a degree of multi-skilling. Workers who performed only one or two tasks during the operational phase may now be required to perform multiple tasks as part of their normal duties. An example might be that during operations, a pipefitter may have only cut and installed piping. During decommissioning this person may also be required to remove piping, perform waste minimization and perform decontamination activities. This may require retraining of this person.

Where operating staff are retrained in certain tasks, this training can be provided under contract from specialists who may go on to supervise the work. In some countries specialist qualifications are being produced for decommissioning workers.

Finally, it is important to recognize that decommissioning project managers may also need retraining if they are to operate as effective decommissioning project managers rather than operating plant managers. One example of qualifications and training of personnel in a decommissioning project is given in Ref. [37]. Because of the potential for the decommissioning to be performed over long time periods, refresher courses and retraining will be required at established intervals or in view of important activities.

7.5.5. Security — safeguards

If spent fuel or other material subject to safeguards (such as plutonium or enriched uranium) remains on the site during decommissioning operations, a security presence will have to be maintained until the material has been removed. Once this material is removed, the safeguards functions can be reduced, but staff will still need to be retained for general security duties.

7.6. INTERFACES

The licensee and decommissioning team cannot perform their duties without interfacing with organizations having involvement or interest in the decommissioning process[1]. This interface may have to go through different parts of the licensee's organization. These organizations provide technical, social or regulatory input to the decommissioning process. Their involvement can perform a valuable review function and provide constructive input to the decommissioning team [17, 38–40]. These organizations typically include:

- Regulatory authorities — nuclear, transportation, environmental protection, radiation protection
- National standards groups, professional societies
- General public — communities, interveners/pressure groups

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[1] A common term for these organizations is 'stakeholders'. A stakeholder is a person or group who can affect, or is affected by, an action.

- Local, regional and national governments
- Waste management organizations — nuclear and hazardous
- Shareholders
- International organizations
- Nuclear industry
- Labour unions
- Customers
- Media.

Figure 8 illustrates typical interfaces. It is important that adequate lines of communications with the organizations are established.

As one important interfacing example, licensing related activities normally continue at a significant level after the decommissioning has been initiated, and staff must have adequate time to continue licensing activities. These activities include possible revisions to the decommissioning plan, safety documents, emergency arrangements, and maintenance and modification procedures.

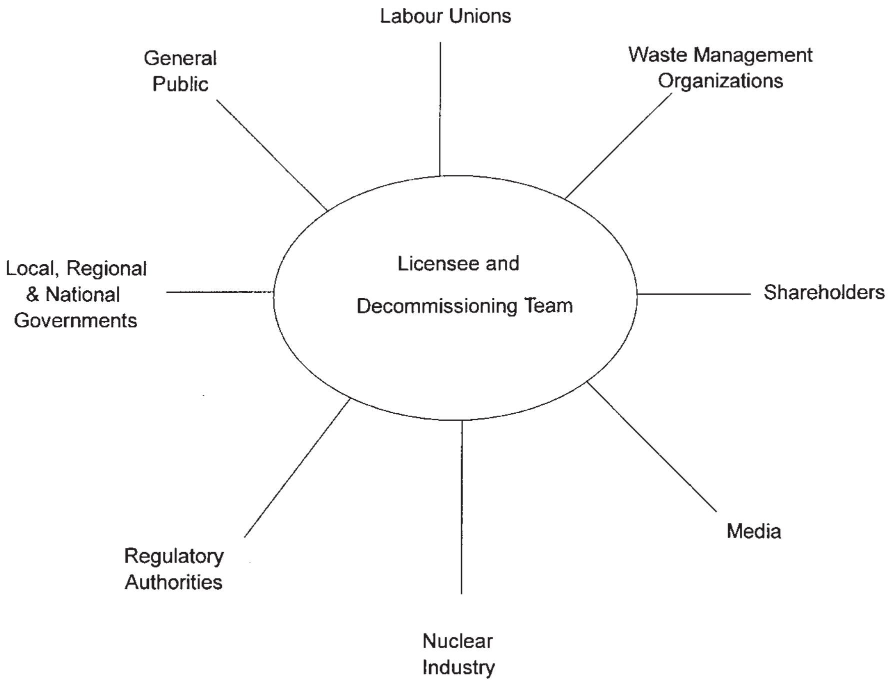

FIG. 8. Typical interfaces with the decommissioning project.

8. CONCLUSIONS AND RECOMMENDATIONS

(1) This report has assessed the processes involved during the decommissioning of large nuclear facilities with respect to organization and management. The decommissioning of a large nuclear facility is a major project. Thus, best project management practices, tools and techniques and QA processes are vital. A dedicated waste management strategy is essential for safe and cost effective decommissioning. Clear lines of communication among all interested parties, responsibilities and accountabilities are of high importance.

(2) A decommissioning project is subject to continuous change. Procedures for the 'management of change' therefore are essential. A timely plan to deal with the social impact that can occur during plant shutdown is often vital.

(3) Clearly stated end states of the decommissioning activities are established. The end states are derived from the objectives of the organization charged with completing the work and are in compliance with the requirements of the regulatory body and other organizations. Further, the agreed upon end states will be readily verifiable, independently measured, and reported in a quantitative way.

(4) The safety of the workforce, public and environment is paramount throughout the decommissioning project.

(5) Adequate funding provisions are essential prior to implementing the decommissioning process, and regular reviews are undertaken to ensure adequate provisions are in place throughout the decommissioning project.

(6) It is important that the Decommissioning Project Manager be identified and the decommissioning team established in adequate time to allow the development and approval of the decommissioning plan. It is important to use a dedicated organization with the necessary responsibilities and qualifications.

(7) Key personnel from the operating facility staff are normally part of the decommissioning management team due to their familiarity with the facility and its systems.

(8) The licensee remains in control and possesses sufficient in-house experience to understand the safety requirements even if use of contractors is made during decommissioning. Assurance is required that contractors provide a service of adequate quality.

(9) The actual organization of the decommissioning team can vary greatly and should be tailored based on the competencies of individual team members, the type of facility, decommissioning strategy and Member State's policies. The team composition may change during the progress of the decommissioning project.

(10) Management of interfaces with organizations external to the decommissioning team is important. This will ensure all interested parties are kept informed of the project progress and have an opportunity to properly manage their input.

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Appendix 1

DATA MANAGEMENT: RECENT EXPERIENCE

An essential aspect of decommissioning planning and organization is data management [1]. A few examples of recent experience are given below.

A code system for management of a decommissioning project has been developed in Japan [2–4]. Various data about JPDR dismantling have been accumulated in a database. These data are being used for: (1) managing ongoing dismantling activities; (2) verifying the code system for management of reactor decommissioning (COSMARD) developed for the use of forecasting management information; and (3) planning future decommissioning of commercial nuclear power reactors [5, 6]. The components that make up the data are: (1) radiation control data; (2) dismantling operations data; and (3) waste management data. This is described further in Annex A–8.

A data management system was set up in the main process building of the Eurochemic Reprocessing Plant, Belgium, which is able to process working hours, production factors, budgeting data for personnel performance, etc. [7], and also at the ‘C’ reactor, Hanford, USA [1].

The databases EC DB TOOL and EC DB COST have been developed within the framework of the European Commission’s 1994–1998 Nuclear Fission Safety programme, in the area of Decommissioning of Nuclear Installations [8]. EC DB TOOL mainly contains technological data, e.g. on dismantling tooling and associated filtration techniques, and EC DB COST comprises data for cost estimations and dose uptakes for unit operations. Currently, developments are undertaken for the EU wide use of both databases.

At the Greifswald nuclear power site in Germany, a data management system called Project Information System has been set up to perform and control the world’s largest ongoing decommissioning project [9]. This information system comprises about 500 work units, the required capacity and costs, masses to be handled and radiological data. It guarantees optimum use of resources. Logistics are most important to maintain the complex material flow. The PC program ReVK has been developed to represent material and waste flows at the Greifswald site, exercise data control within administrative constraints, maintain bookkeeping, generate reports and manage transport and storage resources. With respect to radioactive wastes and final disposal aspects, ReVK includes two other PC programs, i.e. AVK and AVK-ELA. The first is to control radioactive waste flow and the second serves for final disposal purposes [10, 11]. Other software tools have been developed for the assessment of the required volumes and related costs for the disposal of decommissioning waste. For the calculations they take into account the proposed dismantling technique, masses involved, disposal containers available, etc. [12, 13]. A new development towards a more general management supporting system is given in Ref. [14]. More detail is presented in Annex A-6.

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GLOSSARY

clearance levels. A set of values, established by the regulatory body in a country or State, expressed in terms of activity concentrations and/or total activities, at or below which sources of radiation can be released from nuclear regulatory control.

contamination, radioactive. The presence of a radioactive substance or substances in or on a material.

decommissioning. Actions taken at the end of the useful life of a nuclear facility in retiring it from service, with adequate regard for the health and safety of workers and members of the public and protection of the environment. The ultimate goal of decommissioning is unrestricted release or use of the site. The time period to achieve this goal may range from a few to several hundred years. Subject to the legal and regulatory requirements of a Member State, a nuclear facility or its remaining parts may also be considered decommissioned if it is incorporated into a new or existing facility, or even if the site in which it is located is still under regulatory or institutional control. This definition does not apply to some nuclear facilities used for mining and milling of radioactive materials (closeout) or for the disposal of radioactive waste (closure).

decommissioning option. Various decommissioning strategies which may be considered when decommissioning is being planned. A variety of factors, such as timing and the availability of technologies, will influence which decommissioning strategy is ultimately chosen.

decommissioning phase. Refers to well defined and discrete parts of the decommissioning process or work.

decommissioning stages. See decommissioning phase.
Previous IAEA documents have referred to three discrete stages of decommissioning (storage with surveillance, restricted release and unrestricted release). As a result of decommissioning experience, an increasing number of Member States now use different terminologies and approaches, and therefore this glossary no longer refers to the three stages identified above.

decommissioning waste. See waste, decommissioning.

decontamination. The removal or reduction of radioactive contamination by a physical and/or chemical process.

dismantling. The disassembly and removal of any structure, system or component during decommissioning. Dismantling may be performed immediately after permanent retirement of a nuclear facility, or may be deferred.

disposal. The emplacement of waste in an approved, specified facility (e.g. near surface or geological repository) without the intention of retrieval. Disposal may also include the approved direct discharge of effluents (e.g. liquid and gaseous wastes) into the environment with subsequent dispersion.

enclosure, safe (during decommissioning). A condition of a nuclear facility during the decommissioning process in which surveillance and maintenance of the facility take place. The duration of safe enclosure can vary from a few years to the order of 100 years. Also see decommissioning.

fuel, spent (used). Irradiated fuel not intended for further use in reactors.

licence (license). A formal, legally prescribed document issued to the applicant (i.e. operating organization) by the regulatory body to perform specified activities related to the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility.

licensee. The holder of a licence issued by the regulatory body to perform specific activities related to the siting, design, construction, commissioning, operation or decommissioning of a nuclear facility. The applicant becomes the licensee after receiving a licence issued by the regulatory body.

minimization. A concept which embodies the reduction of waste with regard to its quantity and activity to a level as low as reasonably achievable. Waste minimization begins with nuclear facility design and ends with decommissioning. Minimization as a practice includes source reduction, recycling and reuse, and treatment with due consideration for secondary as well as primary waste materials.

operation. All activities performed to achieve the purpose for which the nuclear facility was constructed, including maintenance, refuelling, in-service inspection and other associated activities.

quality assurance (QA). All those planned and systematic actions necessary to provide adequate confidence that an item, process or service will satisfy given requirements for quality, for example, those specified in the licence.

quality control (QC). Action which provides means to control and measure the characteristics of an item, process, facility or person, in accordance with quality assurance requirements.

records. A set of documents, including instrument charts, certificates, log books, computer printouts and magnetic tapes, kept at each nuclear facility and organized in such a way as to provide a complete and objective past and present representation of facility operations and activities including all phases from design through closure and decommissioning (if the facility has been decommissioned). Records are an essential part of quality assurance (QA).

regulatory body. An authority or a system of authorities designated by the government of a country or State as having legal authority for conducting the licensing process, for issuing licences and thereby for regulating the siting, design, construction, commissioning, operation, closure, closeout, decommissioning and, if required, subsequent institutional control of the nuclear facilities (e.g. near surface repository) or specific aspects thereof. This authority could be a body (existing or to be established) in the field of nuclear related health and safety, mining safety or environmental protection vested and empowered with such legal authority.

restricted release or use. A designation, by the regulatory body in a country or State, to restrict the release or use of equipment, materials, buildings or the site because of its potential radiological hazards.

safeguards, IAEA. A verification system within the framework of the international non-proliferation policy applied to peaceful uses of nuclear energy, and entrusted to the IAEA by its Statute, by the Treaty on the Non-Proliferation of Nuclear Weapons and by the Treaty for the Prohibition of Nuclear Weapons in Latin America (Tlatelolco Treaty). For more information, see IAEA/SG/INF/1 (Rev. 1).

site. The area containing, or under investigation for its suitability to construct, a nuclear facility (e.g. a repository). It is defined by a boundary and is under effective control of the operating organization.

storage (interim). The placement of waste in a nuclear facility where isolation, environmental protection and human control (e.g. monitoring) are provided with the intent that the waste will be retrieved for exemption or processing and/or disposal at a later time.

unrestricted release or use. A designation, by the regulatory body in a country or State, that enables the release or use of equipment, materials, buildings or the site without radiological restriction.

waste, decommissioning. Radioactive waste from decommissioning activities.

waste, secondary. A form and quality of waste that results as a by-product from processing of waste.

waste acceptance criteria. Criteria relevant to the acceptance of waste packages for handling, storage and disposal.

waste management, radioactive. All activities, administrative and operational, that are involved in the handling, pretreatment, treatment, conditioning, transport, storage and disposal of waste from a nuclear facility.

Annex A

ORGANIZATION AND MANAGEMENT FOR DECOMMISSIONING OF LARGE NUCLEAR FACILITIES — EXAMPLES OF NATIONAL EXPERIENCE

Examples provided below of organization and management schemes for decommissioning of large nuclear facilities range from national policies and programmes to detailed organizational aspects in decommissioning of specific facilities. It is felt that both approaches are useful to provide practical guidance on how decommissioning projects are planned and managed in various Member States. Examples given are not necessarily best practices; rather, they reflect a wide variety of national legislations and policies, social and economical conditions, nuclear programmes and traditions. Although the information presented is not intended to be exhaustive, the reader is encouraged to evaluate the applicability of these schemes to a specific decommissioning project.

Annex A–1

BELGIUM
(MANAGEMENT OF DECOMMISSIONING AT SCK-CEN)

1. INTRODUCTION

The Nuclear Research Center SCK-CEN in Mol (Belgium) comprises:

- BR1, a graphite–gas reactor in operation for research purposes since 1956;
- BR2, an MTR reactor in operation for research purposes and isotope production since 1961;
- BR3, a PWR reactor operated successfully between 1962 and 1987, at present being decommissioned (see specific Annex A-2);
- research laboratory buildings with hot cells and glove boxes (some laboratory buildings were already decontaminated for clearance);
- an underground laboratory for research on geological waste disposal.

The site restoration unit of SCK-CEN is in charge of the management of the decommissioning of its own nuclear installations.

This document presents the organization of the decommissioning activities at SCK-CEN (see also Annex A–2, related to BR3 decommissioning).

2. ORGANIZATION AT NATIONAL LEVEL

Financing the decommissioning of nuclear installations has been a problem since the early 1980s. Since then, the legal framework for financing the decommissioning of nuclear installations has been developed.

In 1985, the Belgian Government and the utilities signed a specific convention regulating the financing of the decommissioning of commercial power plants.

The financing of the decommissioning of SCK-CEN nuclear installations created by, and under the control of, the Government before 31 December 1988 is ensured by the Belgian Federal Government until 2020 and covers the whole decommissioning and cleanup programme (called Technical Liability). To this end, a convention was concluded in 1991 by the Belgian Federal Government and NIRAS/ONDRAF (National Agency for Radwaste and Fissile Material). The National Agency is in charge of the overall management of the Technical Liability, and SCK-CEN performs the technical activities.

The decommissioning of SCK-CEN nuclear installations created after 31 December 1988 is subject to Royal Decree of 16 October 1991. By this decree, the National Agency is legally bound to collect and assess information on decommissioning of nuclear facilities in Belgium and to approve the decommissioning plans. SCK-CEN is in charge of securing the funding and management of the decommissioning activities for these nuclear installations.

Although decommissioning is reality in Belgium with the decommissioning of the EUROCHEMIC reprocessing facility at Dessel, the BR3 PWR at SCK-CEN (Belgian Nuclear Research Center), four old laboratory buildings at SCK-CEN and the old waste department of SCK-CEN, there is no specific decommissioning licensing procedure at present.

3. ORGANIZATION AT SCK-CEN

The financing of the decommissioning of SCK-CEN nuclear installations, created by research performed before 31 December 1988, is ensured by the technical liability fund that is managed by NIRAS/ONDRAF. SCK-CEN secures its own fund (called Neo-Technical Liability) to cover the decommissioning of the other nuclear installations. The management of both decommissioning activities is centralized in the site restoration unit. The organization chart is given in Fig. 1. The main teams are:

- the technical liability service;
- the waste management service;
- the research and development (R&D) service.

Because of its importance, the decommissioning of the BR3 reactor has its own organization that is described in Annex A–2.

The technical liability service is in charge of:

- producing and updating the physical and radiological inventory of the nuclear installations;
- analysing decommissioning projects (such as BR3 and old laboratory buildings) and setting up unit costs for specific decommissioning activities;
- developing and upgrading the decommissioning management tools for calculating the decommissioning costs (staff, purchase, investment, waste) of a nuclear installation as a function of the strategy adopted;
- setting up decommissioning plans;
- reporting to the national agency;
- evaluating the decommissioning costs of the new installations, and the yearly evaluation of both decommissioning funds.

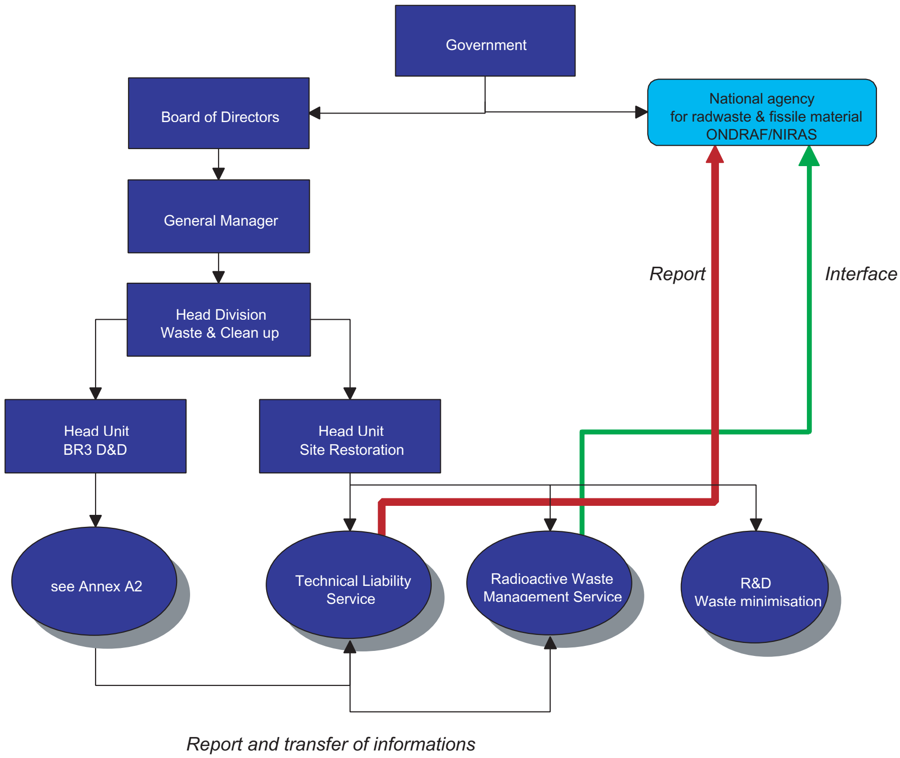

FIG. 1. Organization in the research center (simplified).

The waste management service is in charge of:

- drawing up the official guidelines of waste management at SCK-CEN;
- registering the waste production and movement;
- identifying and making the inventory of the waste streams;
- organizing waste characterization, storage and transport to the treatment facility;
- consultancy to waste producers;
- setting-up decommissioning instructions according to the ALARA approach;
- performing or subcontracting the decommissioning works;
- contacts with the health physics and technical departments.

The R&D service performs research in waste minimization and treatment of special waste (such as beryllium, sodium, graphite and exotic fissile material).

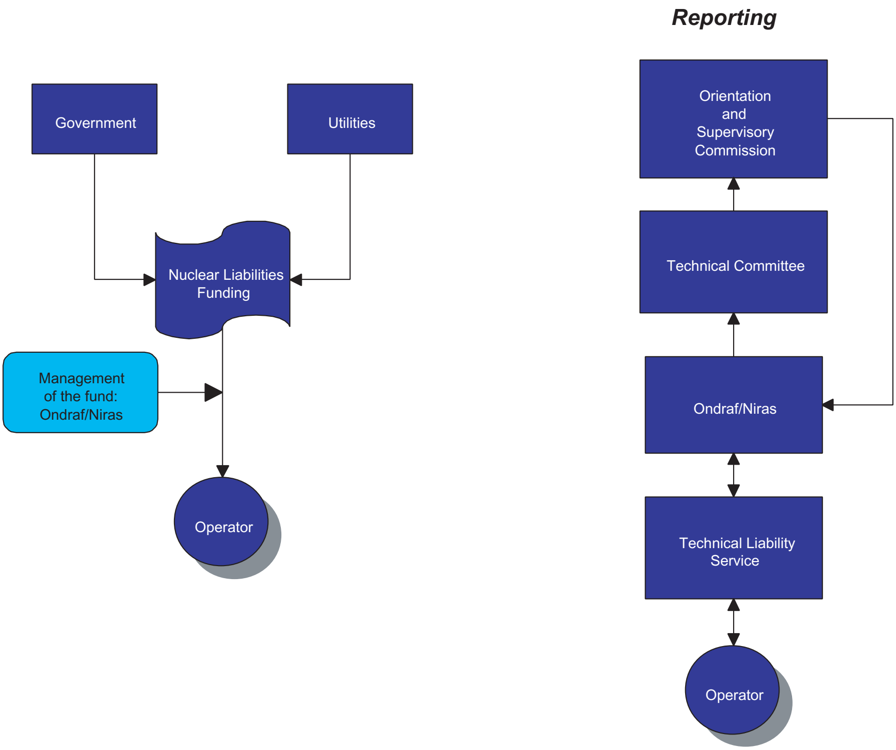

FIG. 2. Organization of the Technical Liability fund.

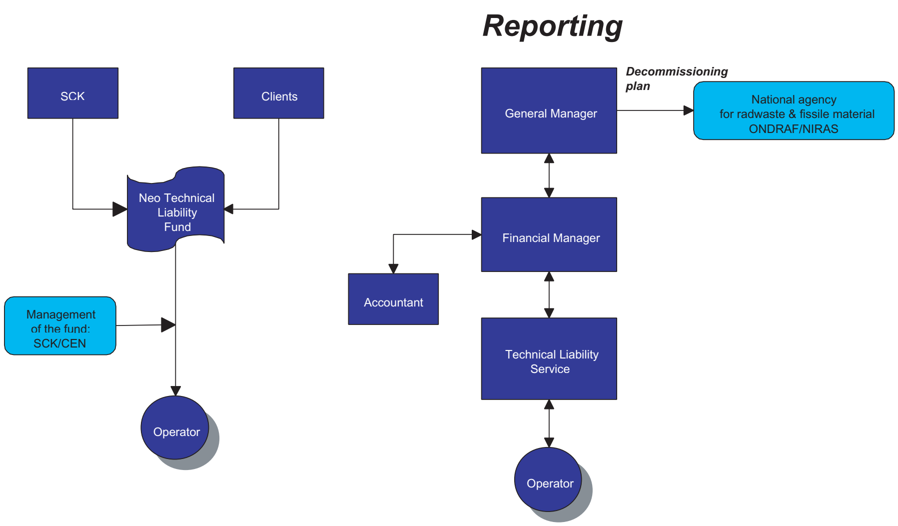

FIG. 3. Organization of the Neo-Technical Liability fund.

Bimonthly, a task force gathers the representatives of each nuclear installation, together with the representatives of technical liability and waste management services.

The decommissioning and cleanup operations performed by SCK-CEN are described in decommissioning plans and yearly programmes. The programme is then submitted for approval to the manager of the fund, i.e. NIRAS/ONDRAF in the case of the technical liability fund and SCK-CEN in the case of the Neo-Technical Liability fund.

In the case of the technical liability fund, the annual work programmes and budgets are presented by SCK-CEN to NIRAS/ONDRAF. If the latter agrees with the proposals, they are submitted for advice to a technical committee and for approval to an orientation and supervisory commission. Both the committee and the commission are composed of representatives of the Federal Ministry of Economic Affairs, the utilities, Synatom and NIRAS/ONDRAF. They meet at least four times per year. The approved programmes are then implemented by SCK-CEN. Figure 2 describes the organization in the framework of the Technical Liability fund.

In the framework of the Neo-Technical Liability fund, the decommissioning and cleanup operations are submitted for approval by the general manager like all other projects at SCK-CEN. Figure 3 describes the organization in the framework of the Neo-Technical Liability fund.

Annex A–2

BELGIUM (BR3 REACTOR)

1. INTRODUCTION

This report, which presents the organization of the BR3 decommissioning project, constitutes one example of the needs and requirements for a large decommissioning project. Some of the organizational and staffing topics are specific to the local or national environment and regulations. The report, is, however, also of interest for all types of decommissioning project.

The national or local safety regulations, specific financing processes, internal organization, etc., have all to be adapted to each decommissioning project or to each operation. Nevertheless, from any specific case some general guidelines can be derived. The return of experience presented will then be generic and probably applicable to different kinds of decommissioning operation.

2. BR3 DECOMMISSIONING PROJECT HISTORY

The BR3 reactor was the first PWR reactor to be installed in western Europe. Put into operation in 1962, it was shut down 30 June 1987. It was a low rated plant with an electrical net power output of 10.5 MW(e) and a thermal power of 40.9 MW(th).

In 1989, BR3 was selected by the European Commission as one of the four pilot dismantling projects, within the scope of the third EC five year research programme on decommissioning of nuclear installations.

The project was divided into two main phases:

(1) Phase 1 (1989–1991), involving:

  (a) the chemical decontamination of the primary loop;
  (b) the selection and testing of techniques and tools for the remote dismantling of the reactor internals;
  (c) the remote dismantling of the first reactor internal (the thermal shield);

(2) Phase 2 (1992–1993), including the remote dismantling of all remaining reactor internals.

Phase 2 was later extended to 1995 and included the dismantling of another set of internals, which has undergone a 30 year radioactive decay period. The aim of this phase is the comparison between immediate and deferred dismantling.

This work is being carried out by the plant owner, the SCK-CEN (Belgian Nuclear Research Center), in association with international partners.

Moreover, within the framework of the decommissioning plan of the plant, thorough decontamination processes for metallic components have been developed and tested. Dismantling and demolition of contaminated and activated concrete has also been studied in preparation for the complete dismantling of the reactor building.

SCK-CEN has gained important experience in cost evaluation, study and operations for the dismantling of nuclear reactors, using in-house staff.

The next step foreseen in the decommissioning project is the dismantling of the reactor pressure vessel and the contaminated circuits of the plant.

3. ORGANIZATIONAL ASPECTS

In organizing decommissioning and dismantling of a reactor, the information flow between the licensee and the different authorities, as well as that to the resources and contractors being used (Fig. 1), has to be managed.

Reporting and information flow concern the following topics:

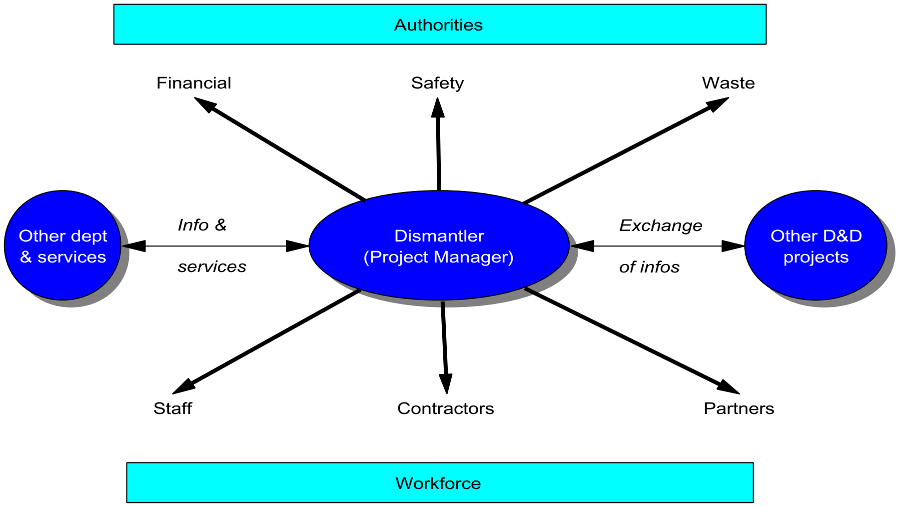

FIG. 1. Minimal links and information streams for the dismantling of research reactors.

- safety
- finances
- waste
- project progress and co-ordination.

Different authorities are often involved in the decommissioning of nuclear facilities and in particular reactors. The following authorities require the information: the safety authorities (up to Government level), the financial authorities (which can be internal or external to the owner of the installation), the agency or institution responsible for waste management and disposal, the local/municipal authorities and even the local communities or the public at large, and the direct management of the licensee and the Board of Governors.

Moreover, if fissile material is involved (e.g. spent fuel left on-site, residues in laboratories or reprocessing plant, etc.), official reporting to the IAEA and Euratom is also required (under the safeguards system).

In order to clarify this concept, the organizational system used for research reactors in Belgium will be briefly described, and generic principles will be deduced from this example.

At a lower level, the organizational structure for the different dismantling and decontamination operations will be highlighted. The required staffing and training will be also described.

4. ORGANIZATION OF THE BR3 DECOMMISSIONING PROJECT IN BELGIUM

To understand how a decommissioning project is organized, it is also important to know the different links and organizational aspects at national and local levels. These links and aspects affect the project itself, its structure and its organization. This section documents the organization of one typical project, but general rules and guidelines can be deduced.

4.1. ORGANIZATION AT NATIONAL LEVEL

Some 15 to 20 years ago, the political decision makers were not concerned with the decommissioning of nuclear installations. Since then, some decommissioning projects have started, and the authorities have had to establish the regulations and standards to be applied. Pilot projects (some of them already started) were then regarded as a basis for establishing regulations of general applicability.

Nevertheless, some organizational aspects common to all nuclear operations are also relevant to decommissioning activities. Some typical or specific aspects were added for this type of activity.

The organizational structure is summarized in Fig. 2, where the system is given for the authorities concerned with safety, waste management and financial reporting. The latter is quite specific in this case. Indeed, research facilities and research reactors were created in the 1950s by the Belgian Government but, up to a few years ago, no provisions were made for the decommissioning of these installations. Therefore, a fund was created for covering these 'technical liabilities'. Through an agreement between the Government and the utilities, this fund was also partially financed by the utilities which used research facilities for their own purposes (training, material research, etc.).

4.2. ORGANIZATION AT THE RESEARCH CENTRE LEVEL

The internal organization for the decommissioning of the BR3 reactor is shown in Fig. 3.

The organization is quite typical, but the reporting structure, due to the 'technical liabilities' funding, implies a second way and an internal co-ordination service for all activities covered by this fund (see also Annex A–1).

4.3. ORGANIZATION AT THE REACTOR DECOMMISSIONING TEAM LEVEL

This organization implied smooth transition from an operating reactor to a reactor in a decommissioning phase. Moreover, some of the team members from the operational period remained on-site and contributed a good deal of knowledge and experience concerning the operation of the installation.

The present organization chart is given in Fig. 4.

Three main teams are, at present, responsible for:

- decontamination, waste management and R&D;
- dismantling operations;
- supporting activities, survey and maintenance of the plant and equipment.

The team responsible for decontamination of materials follows the waste stream to the radwaste conditioner and intermediate storage facility. It comprises an R&D group as well as a group responsible for safety and the ALARA approach to the different operations.

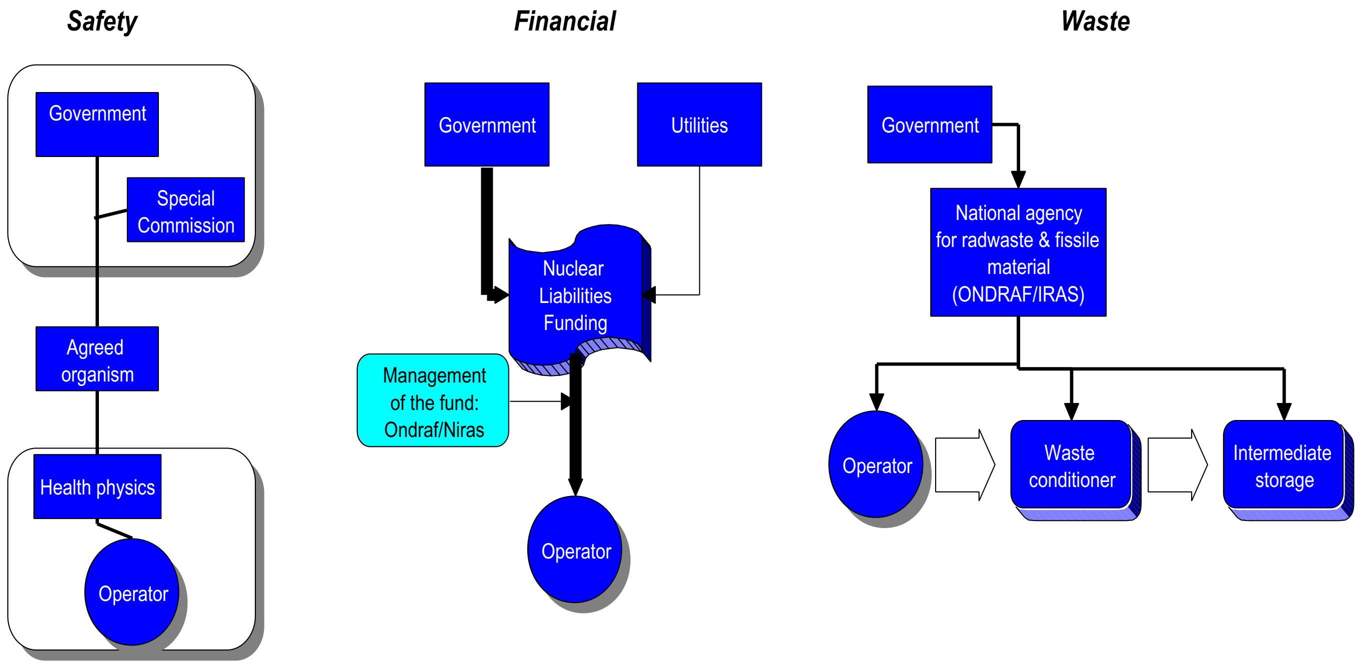

FIG. 2. Organization at national level (simplified).

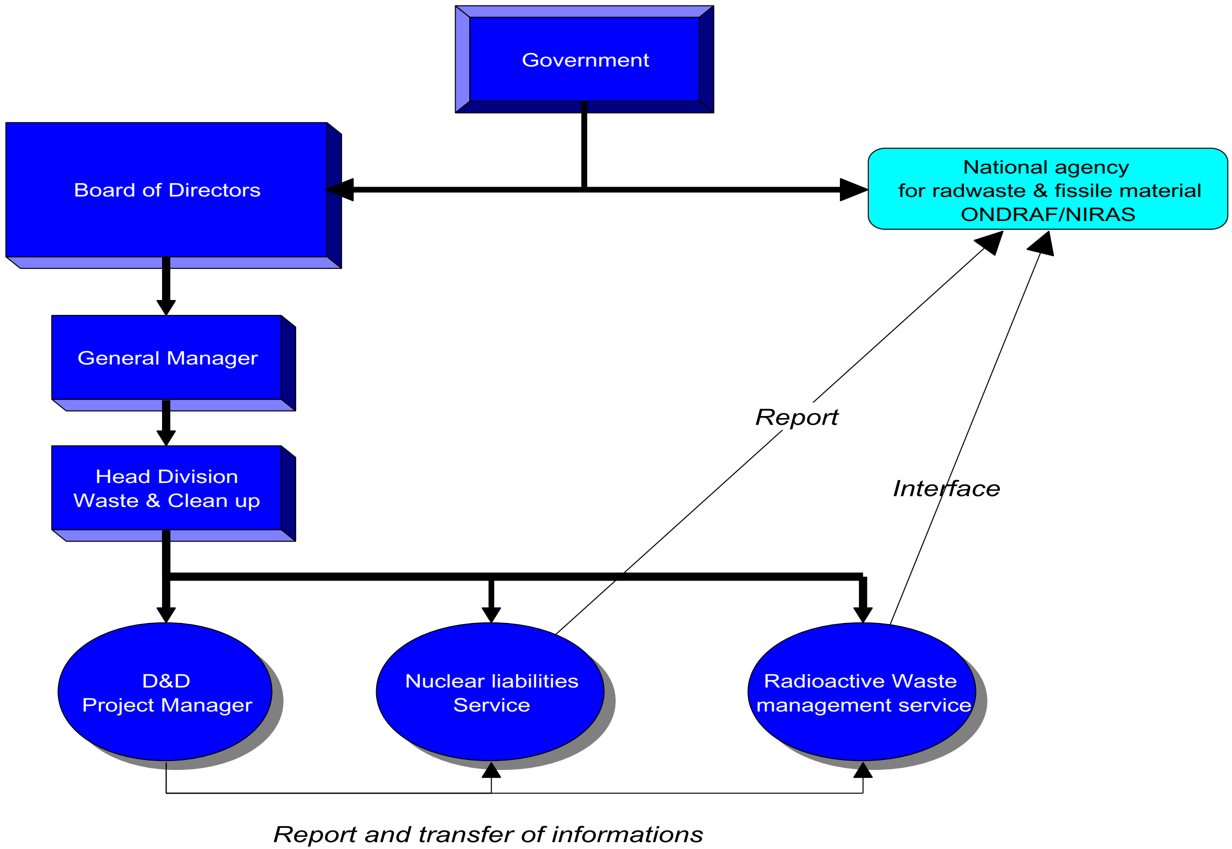

FIG. 3. *Organization in the research centre (simplified).*

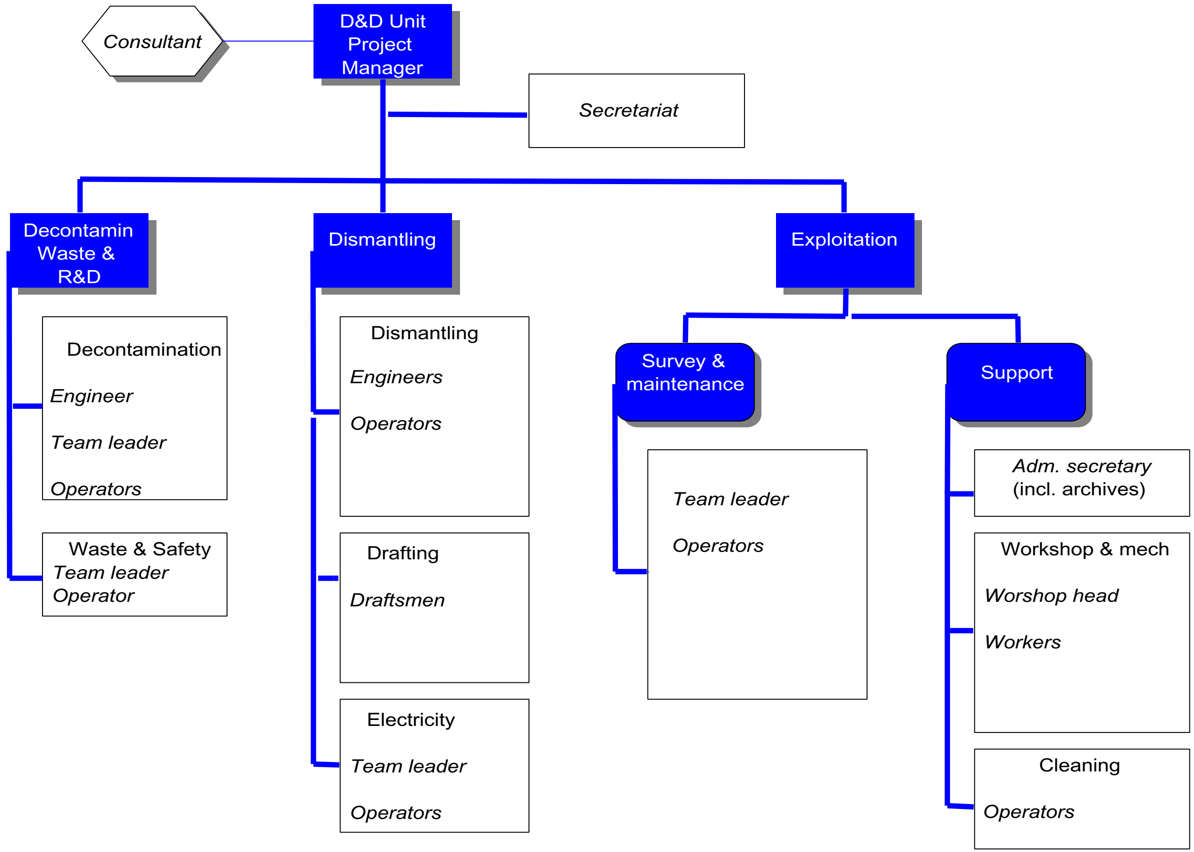

FIG. 4. D&D team organization.

The exploitation team is comprised of a ‘support group’ (cleaning and mechanics) originating from the power plant maintenance team, and a ‘survey and maintenance’ group derived from the exploitation team of the plant. The latter is important for preparation of the dismantling of loops and knowledge of the installation. The group is also responsible for maintaining the plant in a safe condition during dismantling. The support group assists the different dismantling and decontamination operators.

5. ORGANIZATION OF OPERATIONS AND STAFFING

The dismantling operations are organized as shown in Fig. 5.

This organization assures good co-ordination of work.

The amount of material generated is quite significant, and there are various methods of treatment (e.g. physical or chemical decontamination, size reduction) and release (e.g. clearance with or without melting, melting for recycling, destination as radwaste), so that the material flow becomes quite complex (see also Section 6).

The dismantling project is subdivided into tasks. Each task itself is further subdivided into subtasks. For example, the dismantling of the high active thermal shield is one task. The dismantling of the thermal shield using the milling cutter is one elementary subtask.

For each subtask, the following subsequent steps exist:

- preparation;
- work execution;
- waste handling.

During the preparation stage, the main activities performed are:

- detailed study of the subtask;
- selection of the technique used;
- design and purchase of the necessary equipment and tools;
- drafting of work procedures;
- cold testing of the technique: for cutting equipment, cold tests with mock-ups are systematically performed to define the right parameters, train the operators and solve operational issues;
- planning of staff requirements;
- ALARA evaluation;
- estimation of waste streams;
- physical preparation of the workplace.

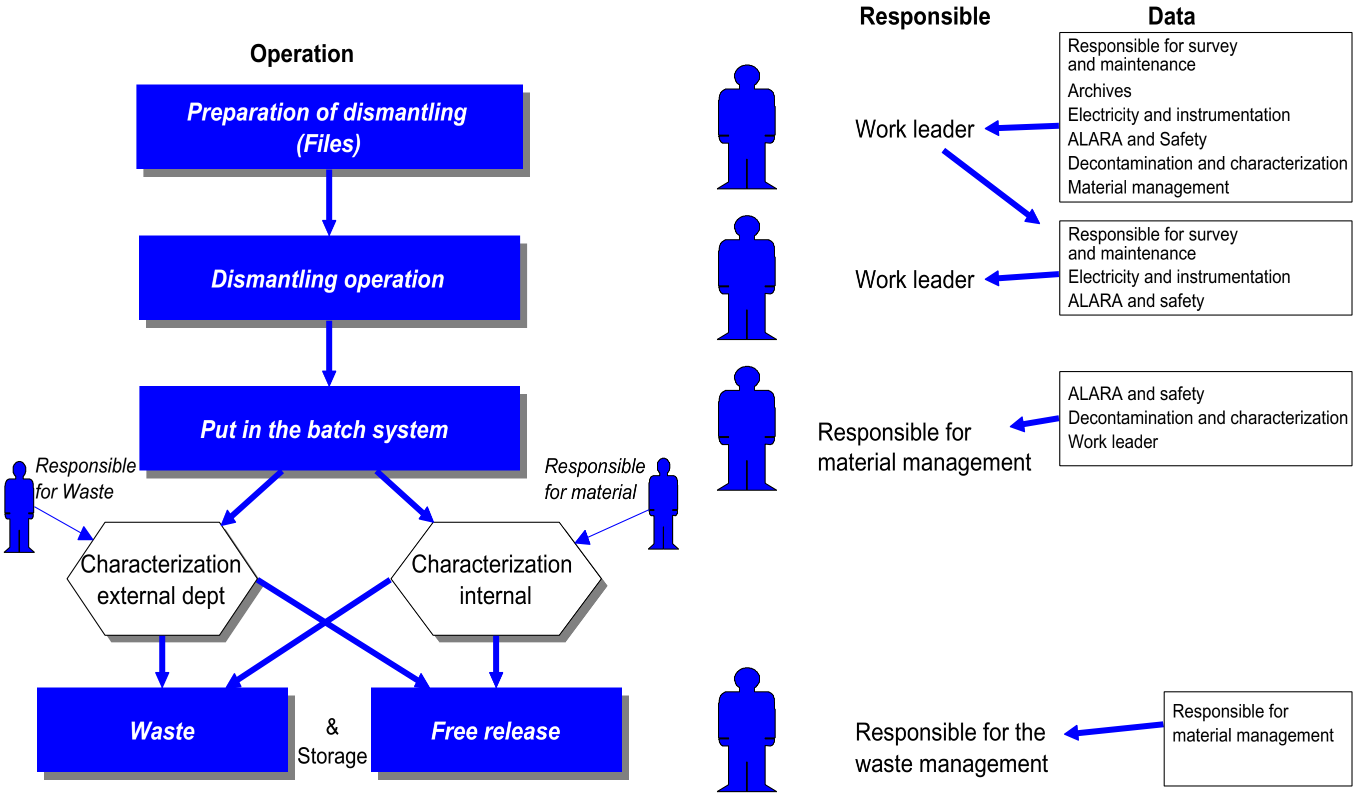

FIG. 5. Organization of dismantling operations.

Before starting the work execution itself, a document containing the safety and ALARA assessments is submitted to the health physics department, which analyses the work from the points of view of radiological exposure and conventional safety. Work must not start before formal approval by the health physics department, which may request modifications to the work procedure.

The on-site work is then performed. The dismantling team comprises at least one responsible person (supporting staff), one or several reactor operators, one or several reactor supervisors and one health physicist. Besides their own personnel from BR3, some technical assistance by partners or subcontractors is needed. During a specific dismantling operation, cleaners and mechanical and electrical technicians are available on request.

When the operation is finished, a thorough analysis is performed on:

- staff effectively used compared with staff planned;
- problems encountered and solutions;
- possible revision of work procedure or techniques employed;
- dose exposure (ALARA analysis).

Finally, the materials arising from the dismantling operation must be removed. This step comprises the following actions:

- complete characterization of the materials;
- selection of the removal route;
- removal of the dismantled materials.

These steps are performed under supervision of the health physics department. The control organization (AVN), which reports to the competent authority (Ministry of Health), controls the site health physics department.
Three main evacuation routes are followed for materials/waste:

- the material can be disposed of as radioactive waste;
- the material can be recycled within the nuclear industry, for example, by melting;
- the material can be free released.

If the material is disposed of as radioactive waste, the specifications of the official organization for radwaste management (NIRAS/ONDRAF) have to be respected. Radwaste conditioning is performed mainly by Belgoprocess, which is the daughter company of NIRAS/ONDRAF. Belgoprocess can condition and store low, medium and high level waste. The conditioned waste is stored on the

Belgoprocess site, awaiting final disposal. There are not yet any disposal sites available in Belgium.

If the material is recycled within the nuclear industry, the specifications of the user have to be respected. Up to now, only recycling by melting has been performed. Limits are given by the smelter in terms of radiation levels and radionuclide concentration.

If the material is to be free released, the authorization is given by the site health physics department. The clearance document is then submitted to the AVN for approval. The limits used are either based upon surface contamination measurements or specific activity measurements.

For the dismantling of highly active materials (e.g. reactor internals or pressure vessel), the techniques used (mostly, remote controlled ones) are more sophisticated. Therefore, the preparation step takes more time and usually requires the use of the engineering office (draftspersons and engineers) as well as more cold testing and training (see also Section 7 of this Annex on training).

For the dismantling of contaminated loops and equipments, the characterization, co-ordination and follow-up of the material stream is the most important part of work management.

6. MATERIAL FLOW MANAGEMENT

The dismantling of nuclear installations and, in particular, of reactors generates a large amount of materials that are either activated, contaminated or suspected to be contaminated.

These materials have to be identified, characterized and measured. Moreover, in order to dispose of them, their history and treatment/handling steps have to be known.

The materials (pieces of equipment, metallic parts, concrete rubble, etc.) can have different evacuation routes, depending on residual contamination, geometrical shape, history, etc. The different ways used at BR3 are as follows: direct clearance, melting for clearance, melting for recycling, and destination as radwaste.

When a loop or equipment is dismantled, the generated materials are sorted in ‘batches’ of similar items (e.g. valves, pipes) coming from the same loop. A unique identification number is assigned to each batch, and a form is attached to the batch. This form will follow the batch up to its final disposal (job follower), the different steps of handling and treatment being indicated on the batch form.

These data are also recorded on computer, allowing continuous overview of the dismantling situation. Moreover, with the origin of the batch being known, the system allows the dismantling to be linked with the installation inventory and the progress of the overall project to be followed.

7. TRAINING AND COLD TESTING

Training of the personnel involved with dismantling activities is primarily concerned with safety and radioprotection principles. Persons involved in the dismantling of contaminated equipment and loops can be exposed to direct radiation, but are more likely to be exposed to airborne contamination. Prevention against these hazards must be understood by the workers. For the dismantling of highly active pieces, the training of the operators on real scale mock-ups was very successful.

Cold testing on full scale mock-ups presents various advantages:

- solution of potential problems in dismantling of equipment and machinery in a convenient, non-active environment;
- definition of the best cutting or operating parameters of the machine, thus reducing the intervention time (and, consequently, dose uptake) to the workers;
- training of workers assigned to maintenance and tool exchange on the cutting and dismantling machine, which once again reduces the working time and exposures;
- better planning of secondary waste minimization.

Experience from BR3 has proved that full scale model testing optimizes the operation. The only operation that was not tested on ‘cold’ pieces raised many problems, which needed much time and money to be solved.

8. CONCLUSIONS

Experience and lessons learnt during the BR3 pilot decommissioning project have highlighted some important organizational aspects of waste and material management, internal work organization and personnel training.

Other organizational aspects, at a higher level, together with the accompanying information stream, are probably also quite common to all decommissioning projects; decommissioners of reactors should thus be prepared for adequate information management.

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Annex A–3

CANADA (AECL DECOMMISSIONING PROJECTS)

1. INTRODUCTION

The size and complexity of the organizational structure required to effect a decommissioning project is largely dependent on the magnitude of the nuclear research and/or nuclear power programme operated in a country. In general, nuclear programmes are large, as a result of the components necessary to develop and operate a meaningful programme. Accordingly, the programme size will dictate the size and organizational structure of the decommissioning group responsible for carrying out the programme. Continuity is particularly important since the decommissioning programme is likely to span decades.

The key elements of the organizational structure are made up of the strategic organization, the operational project and the technical/administrative organizations. These elements will be discussed in the subsequent sections.

Since AECL has a relatively large nuclear programme, which has been in operation for over 50 years, the organizational structure of decommissioning is relatively well established. However, the structure continues to evolve as older facilities become redundant and larger operational decommissioning projects develop.

2. ORGANIZATIONAL STRUCTURE

2.1. Strategic organization

Strategic organization is likely to be the most important element of a well developed decommissioning organization. The responsibility for identifying the priorities of the programme and balancing these with funding availability rests with this element. The strategic element is instrumental in defining the overall funding levels and the structure of the underlying operational organization which plans and implements the operational decommissioning projects.

The strategic organization must be closely associated with the funding source and strategy and must develop an overall programme that meets all current and long term regulatory, environmental and public safety requirements. The strategic organization must plan well into the future, probably for over 100 years.

2.2. Operational/project organization

The operational/project organization is responsible for planning, managing and executing all phases of identified decommissioning projects. This includes development and organization of appropriate teams to cover a broad range of functions such as:

- Operational experience/knowledge base
- Licensing
- Radiation protection
- Health physics
- Environmental assessment
- Environmental monitoring
- Waste management
- Quality assurance
- Records maintenance.

Typical organizational structures are shown in Figs 1 and 2.

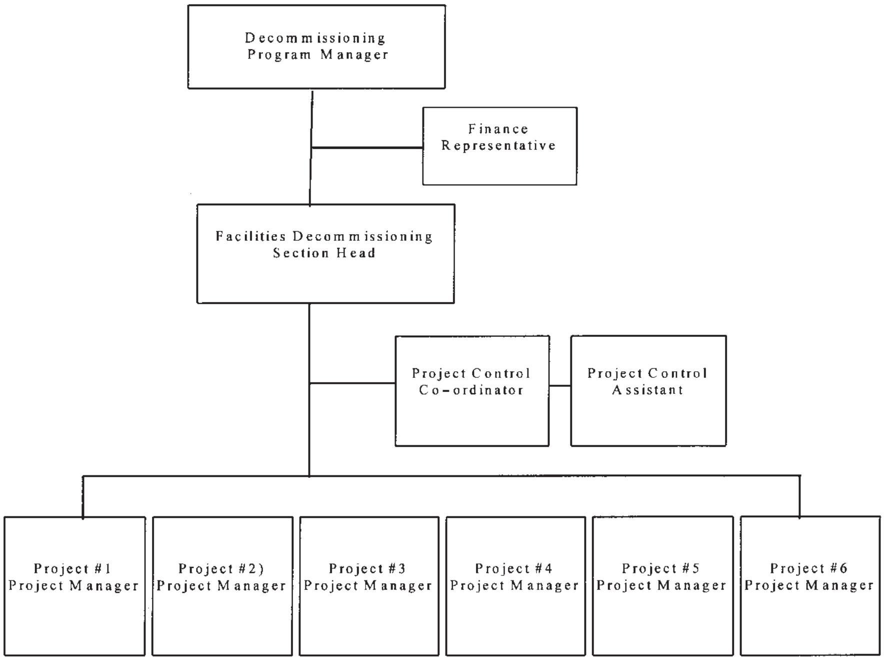

FIG. 1. Programme organization of facility decommissioning.

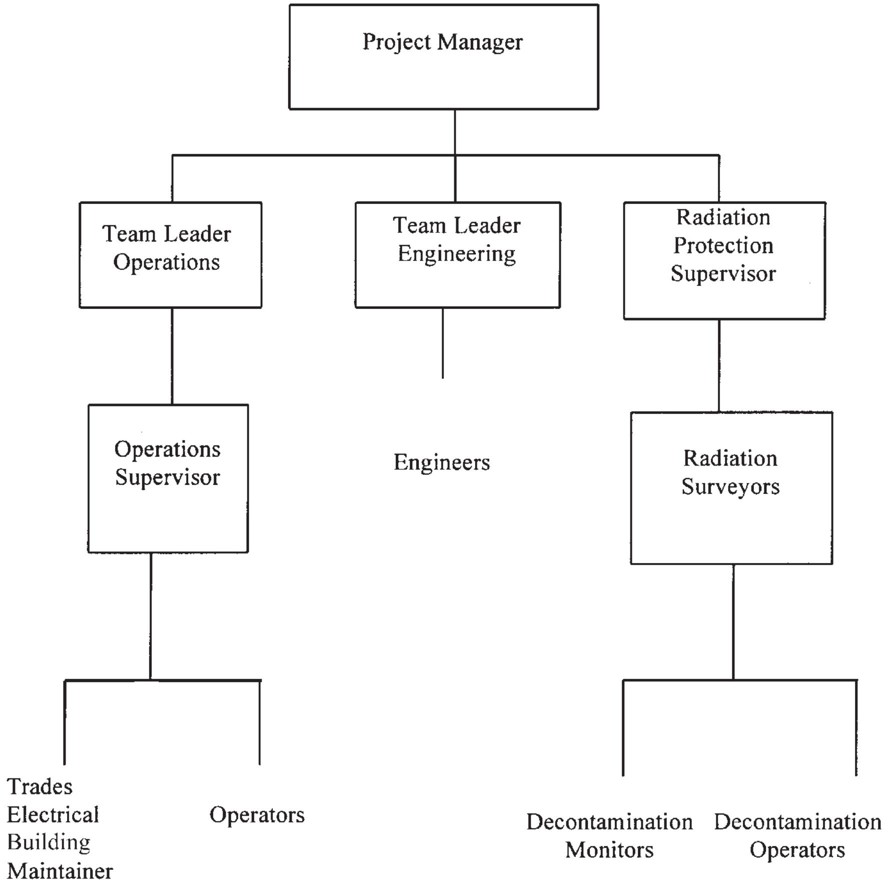

FIG. 2. Typical project organizations.

2.3. Technical/administrative organization

These structures are generally available as a consequence of operating a nuclear programme, and the decommissioning programme draws upon such resource groups to provide the expertise needed to support individual decommissioning projects. Available key resource groups usually include:

- Safety and licensing
- Environmental protection
- Nuclear physics
- Radiation protection, health physics

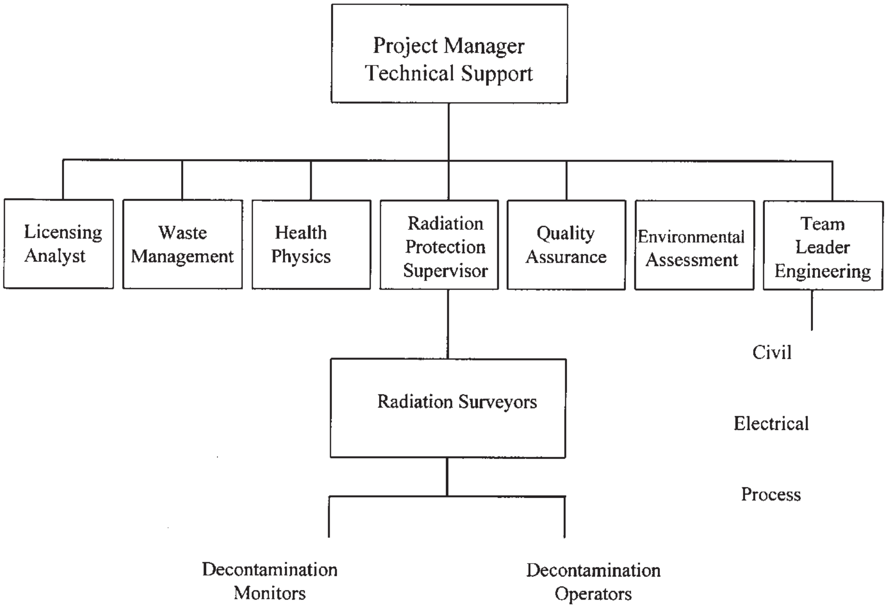

FIG. 3. Technical support organization.

- Reactor operations
- Human resources
- Finance
- Procurement.

As an alternative, where staff or expertise is not adequately available in-house, these resources can be contracted from other organizations. This can provide for good streamlining of resource levels to scheduling demands. A typical technical support structure for a decommissioning project is shown in Fig. 3.

3. DECOMMISSIONING PLANNING

3.1. Strategic planning

Strategic planning must consider all decommissioning activities required to meet the long term needs of the nuclear industry of an entity or country. Although initially the focus tends to be on immediate decommissioning requirements, the structure should ensure that decommissioning planning is factored into all new nuclear facilities in order to minimize future costs and radiation dose exposures.

The strategic element needs to confirm and establish a relationship with a funding source (in Canada, this is currently a separate appropriation from government) and to define the cash flow over a long period in order to meet current and anticipated decommissioning projects. This requires a close link to the overall nuclear business strategy to determine the facilities which will become redundant and will require decommissioning activity over a period which may extend up to more than 100 years. This group must also define the decommissioning strategy to be followed over the long term. A typical Canadian strategy [1] for research reactor decommissioning is given in Table I [2–4].

3.2. Detailed decommissioning plan

The detailed decommissioning plan sets out the detailed work programme, safety and environmental protection procedures and management systems that will be

TABLE I. DECOMMISSIONING STRATEGY

IAEA Guidelines [2–4]	Definition	Reactor phase	Typical research activities
Stage 1	Storage with surveillance, removal of fuel, fluids and other mobile radioactive sources.	Phase 1	Remove fuel and heavy water from the facility. Shut down facilities/systems to provide a safe, secure monitoring/ surveillance state. Decontaminate the fuel bays complex.
Stage 2	Restricted site release. Dismantling of service systems and securing isolation of reactor and contaminated process systems.	Phase 2	Dismantle and decontaminate in order to remove significant accessible sources, secure reactor and remaining contaminated process systems.
		Phase 3	Deferment period
Stage 3	Unrestricted site use. Removal of reactor and remaining contaminated/ activated materials.	Phase 4	Removal of reactor and remaining contaminated systems. Decontamination of site to meet use or release requirements.

followed in the decommissioning of a facility. In AECL this plan must be approved by an internal safety review committee and externally by the Atomic Energy Control Board regulators before any decommissioning work can take place.

The following is a guideline for preparation of a detailed decommissioning plan including suggested subjects headings and brief descriptions of contents.

Introduction/background

- The objectives of the decommissioning plan.
- A description of the facility and the decommissioning boundaries.
- Pertinent historical/operational information.
- Diagrams showing the location of the reactor site, the facility layout and boundaries.
- Current status of the facility.

End state

This section should describe the end state selected for any phase of decommissioning being undertaken. Where deferment is part of the strategy this section should outline the interim end state documentation to be produced to detail the condition of the facility for the deferment period. The requirements and methods for access control and the monitoring/surveillance and maintenance requirements for the deferment period are also detailed as part of this documentation. The interim end state document is used as the basis for revision of the licence, to reflect the reactor condition in a monitoring/surveillance state consistent with the decommissioning level achieved.

Principal hazards

This section documents the results of comprehensive and systematic surveys of the radiological and other potentially hazardous conditions at the facility. Also included is the identification and description of any remaining significant gaps or uncertainties in the measurement or prediction of potentially hazardous conditions.

For research reactors, hazards are generally categorized according to criticality, radiation, chemical and industrial hazards. Typical hazards under each category may include:

Criticality hazards

- Irradiated fuel
- Unirradiated fuel.

Radiation hazards

- Irradiated fuel
- Heavy water moderator (tritiated)
- Water filled trenches and fuel storage bays
- Water collection sumps
- Contaminated/activated/irradiated material stored in fuel bays
- Activated reactor vault components
- Contaminated process systems
- Stored materials in storage blocks
- Loop components in shielded rooms
- Glove boxes and associated lines
- Loose contamination in accessible areas around the facility.

Chemical hazards

- Graphite reflector
- Lead–acid batteries
- Asbestos insulating materials (building, system piping, etc.)
- Small amounts of industrial chemicals
- Mercury switches
- Lead based paint
- Lead bricks and sheet
- Organic coolant in loops
- Refrigerants in cooling/ventilation systems
- Depleted uranium in storage
- Fluorescent light fixture ballasts.

Industrial hazards

- Building structures and height work
- Cranes
- Building service systems.

As part of the hazards identification, a comprehensive radiation survey should be carried out to provide a well documented record of radiation fields after a shutdown period. This record should be maintained as a database against which comparisons can be routinely made throughout various phases of post-shutdown and decommissioning work to gauge the effectiveness of decommissioning activities and time in reducing radiation fields.

Decommissioning rationale/strategy

An overview of the decommissioning, including its rationale in terms of the overall decommissioning strategy outlined by the strategic organization, is given.

Work package descriptions

These include:

- description of the tasks in each work package, including the sequence of tasks;
- the nature and source of any hazards with potentially significant risks posed to workers, the public and the environment, including estimates of doses;
- reference to the specific standard or project specific procedures/technologies proposed to mitigate those risks;
- the quantities, characteristics and disposition of wastes arising.

A table is suggested as an appropriate means of summarizing the work package description elements. The complexity of the work package structure should reflect the hazardous characteristics of the facility.

Project management

Project management includes the schedule, budget and project organization.

The schedule provides workpackage level of detail. The budget includes cost estimates to workpackage level of detail. The project organizational structure should be described.

Waste management plan

The waste management plan describes the waste categorization that will be done (i.e. active, non-active, hazardous, non-hazardous), including

- criteria
- methods description
- instrumentation
- clearance levels to be used.

The waste management plan also includes estimates of waste quantities (volume, weight) expected in each category.

Specific plans for reuse, recycling, storage or disposal of the waste will be described.

Environmental assessment

This section outlines the level of environmental assessment which will be required to ensure that the environmental effects of the project are identified and that solutions to problems are incorporated in the plans before work commences.

Other considerations

This section includes details of the quality assurance, emergency response, security, training, and industrial safety programmes.

3.3. Quality assurance

The decommissioning management structure is generally committed to the implementation of a quality assurance programme to ensure compliance with relevant organizational (e.g. AECL Corporate QA) and regulatory requirements (e.g. AECB regulatory document R-90 [5]). A plan should be in place to ensure that:

- decommissioning activities at a facility are conducted in accordance with the terms and conditions of applicable licences;
- the objectives and requirements specified in the respective overall decommissioning plan for each redundant facility are covered;
- work is performed according to approved work plans covering all site activities including verification activities;
- the safety of public and workers is protected;
- changes to project specific procedures and project documents referenced in the licence are controlled and submitted to the relevant regulatory authority for prior review and approval.

Typically, a project specific quality plan is prepared to ensure appropriate QA for the duration of a decommissioning project. The specific items addressed under each area include:

Management functions

- Organizational structure
- Organizational responsibilities
- Personnel qualification and training
- Project procedures
- Audits
- Corrective actions

- Work stoppage
- Programme review
- Site security
- Emergency procedures
- Safety programme
- Health physics programme
- Procurement activities
- Interface control.

Performance functions

- Work control
- Detailed work plans
- Field instructions
- Worker protection
- Document control
- Operating systems (identification, maintenance and modification)
- Measuring and test equipment
- Radiological protection
- Radiological zones
- Decontamination
- Criticality prevention
- Change control
- Non-conformance reports.

Verification functions (e.g. QA procedures, work plans, performance) and records identification and control are also outlined in the plan.

3.4. Records and documentation

All relevant documentation relating to the design, construction, commissioning, operating and decommissioning phases of the facility should be retained through the entire decommissioning period. Where deferment is part of the strategy, it is important to ensure secure long term storage for such records.

Relevant records can be defined under three broad categories as outlined below.

(i) Design and construction records

Information on the physical characteristics of the facility should be retained for use in the decommissioning plan. Design details include manuals, drawings and photographs that describe the facility ‘as built’ including subsequent modifications. Visual records gathered during construction may be especially helpful.

(ii) Commissioning and operating records

Commissioning and operating records include reports and documents that describe the following:

(a) relevant operating history and physical modifications to the facility;
(b) types, quantities and properties of radioactive and other hazardous materials produced in, or brought into, the facility, the purposes for which they were used, and their storage and use locations;
(c) discharges and spills of radioactive and other hazardous materials that have contaminated or may have contaminated the facility or the local environment;
(d) actions carried out to clean up spills of radioactive and other hazardous materials;
(e) the results of surveys of radiation dose rates and radioactive contamination levels in the facility and its environs;
(f) the results of surveys for other hazardous materials in the facility and its environs; and
(g) accidents, failures or malfunctions that my have affected the integrity of structures, systems or equipment.

(iii) Decommissioning records

Decommissioning records include:

(a) the decommissioning plan;
(b) the procedures used in decommissioning;
(c) reports and other documents that describe:
    (i) the criteria used to define radioactive and other hazardous materials and to distinguish contaminated from uncontaminated materials;
    (ii) the criteria used to define the final decontaminated state of the facility;
    (iii) the principles and models used in deriving the radioactivity and decontamination criteria;
    (iv) the effectiveness of decontamination processes or methods used;
    (v) the amounts of radioactive and other hazardous materials removed and their disposition;
    (vi) the equipment and materials removed from the facility for recycling, treatment prior to removal from the site and disposition;
    (vii) the survey methods and the types of instruments used; and

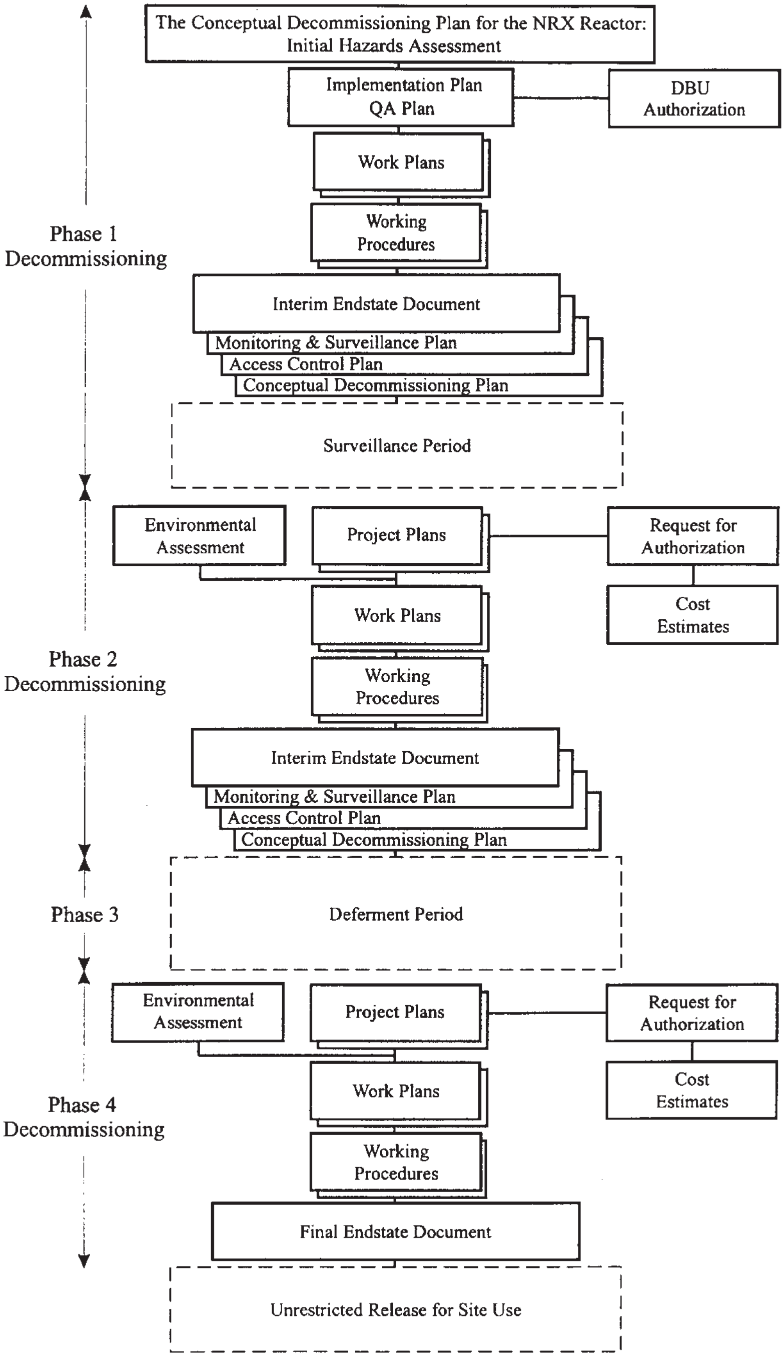

FIG. 4. Document hierarchy.

(viii) the equipment, materials and structures remaining at the end of decommissioning.

A typical document hierarchy containing a range of documents prepared to plan and control the decommissioning activity is shown in Fig. 4.

4. SUMMARY

A well developed organizational structure is critical to carrying out reactor decommissioning because of the complexity, cost and long time frames involved in planning and completing such projects. The strategic organization sets the decommissioning strategy, develops long term funding plans and develops the operational/project structure required to implement projects. The availability of technical and administrative resource groups is also an asset to planning and implementation.

With a well developed organizational structure, the processes required to control decommissioning projects are developed and maintained. This provides a structural approach to all phases of decommissioning including the preparation of detailed plans and procedures, quality assurance programmes, and records and documentation retention and control systems.

REFERENCES TO ANNEX A–3

[1] HELBRECHT, R.A., TAYLOR, D.B., The Conceptual Decommissioning Plan for the NRX Reactor: Initial Hazards Assessment AECL RC-1040 (Rev.01).

[2] INTERNATIONAL ATOMIC ENERGY AGENCY, Decommissioning of Nuclear Facilities: Decontamination, Disassembly and Waste Management, Technical Reports Series No. 230, IAEA, Vienna (1983).

[3] INTERNATIONAL ATOMIC ENERGY AGENCY, Factors Relevant to the Decommissioning of Land-Based Nuclear Reactor Plants, Safety Series No. 52, IAEA, Vienna (1980).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Safety in Decommissioning of Research Reactors, Safety Series No. 74, IAEA, Vienna (1986).

[5] ATOMIC ENERGY CONTROL BOARD, Policy on the Decommissioning of Nuclear Facilities, AECB-R-90, Atomic Energy Control Board (1988).

Annex A–4

CANADA (GENTILLY-1 REACTOR)

1. BACKGROUND

Gentilly-1 is a 250 MW(e) natural uranium fuelled, heavy water moderated and boiling lightwater cooled nuclear power plant located on the south shore of the St. Lawrence River in the Province of Quebec, close to the City of Trois-Rivières. The plant is owned by AECL and was operated by Hydro Quebec. During the period of 1972 to 1979, it operated intermittently for a total of 183 effective full power days.

In 1978, it was determined that certain modifications and considerable repairs would be necessary if the plant were to continue in service. Accordingly, pending a decision on its ultimate disposition, the plant was taken out of service in April 1979. The reactor was defuelled and the heavy water was drained out of the systems in June 1981. Essential operations and maintenance services continued with reduced operating staff.

In July 1982, it was decided to retire the plant as, for economic reasons, its rehabilitation was not worth while. Engineering and economic studies were carried out to find use for some of the facilities of the plant and further reduce the operating and maintenance costs during long term interim storage of the plant in a static mode with surveillance. On the basis of the above studies, a two year decommissioning programme was launched in 1984.

2. PROGRAMME OBJECTIVE

The main objectives for the programme were:

- To reduce operating and maintenance costs during long-term interim storage at the plant in a static mode with surveillance. Decision on the final disposition of the plant (including dismantling and unrestricted release of the site) will be taken at an appropriate time in the future.
- To reduce radiological risks during the long term interim storage period.
- To release some of the facilities in the plant for unrestricted use.
- To salvage some equipment with resale value.
- To gain experience in decommissioning activities such as decontamination, waste handling and dismantling.

3. PROGRAMME SCOPE

The scope included the following major activities:

- Transfer of new fuel bundles off-site.
- Construction of 11 irradiated fuel bundle storage canisters at the west end of the turbine building and storage of irradiated fuel bundles in these.
- Dismantling and removal of all equipment, piping, cabling, partition walls, suspended ceilings, etc., from designated parts of the service and turbine buildings. Decontamination of building shells and spent fuel bay and transfer to Hydro Quebec for use in a simulator and training centre.
- Bringing the reactor building, designated parts of service and turbine buildings, pump house, guard house, spent resin tanks and dry active waste storage area to a defined end state for interim storage.

To estimate costs and to implement and control work, the programme scope was distributed in a number of work packages, a list of which is shown in Table I. The project costs were about $25 M (Cdn.) over a two year period (1984–1986).

4. PROJECT ORGANIZATION

The organization consists of a number of project dedicated groups (see Section 4.1) reporting to the station and project manager. The station and project manager, in turn, reports functionally and administratively to the manager of projects. To retain operational independence from all projects relating to Gentilly-1 decommissioning, the QA engineer and the licensing supervisor report administratively to the manager of projects, but functionally to the respective functional groups outside the projects groups within AECL. The project dedicated groups, except the health and safety group, report administratively and functionally to the station and project manager. Again, to retain some operational independence, the health and safety group reports administratively to the station and project manager but functionally to a group outside the project.

4.1. PROJECT DEDICATED GROUPS

- Station and project operations
- Spent fuel handling operations
- Project services
- Resident engineer

TABLE I: LIST OF WORK PACKAGES

Title	Remarks
Public relations	Co-ordination for finding a new vocation/use for the reactor building
Owner's representative	Manager of projects and QA
Site operations	Operations and maintenance on-site and site labour
Decontamination	Work associated with the modifications in the service building and turbine buildings for transfer to Hydro Québec
Resident engineering	Engineering for spent fuel storage, building isolation and service building enhancement
Project management	On-site. Includes project manager, technical consultant and secretary
Site services	Planning and scheduling, administration, finance and procurement
Radiation protection	On-site
Fuel handling	Spent fuel storage support to project from AECL engineering laboratory
Licensing supervision	
Engineering design review	
Health physics	On-site
Health and safety	Health physics support to project from AECL
Finance, accounting and procurement	Support services to project from AECL

- Health and safety
- Radiation protection and radiological survey
- Decontamination
- Security.

Figure 1 shows the decommissioning project organization. It should be noted that the staff shown in the figure does not reflect the total staff requirements at the site. Non-radioactive demolition/dismantling and maintenance and modification work were carried out by private contractors, employing their own workforce.

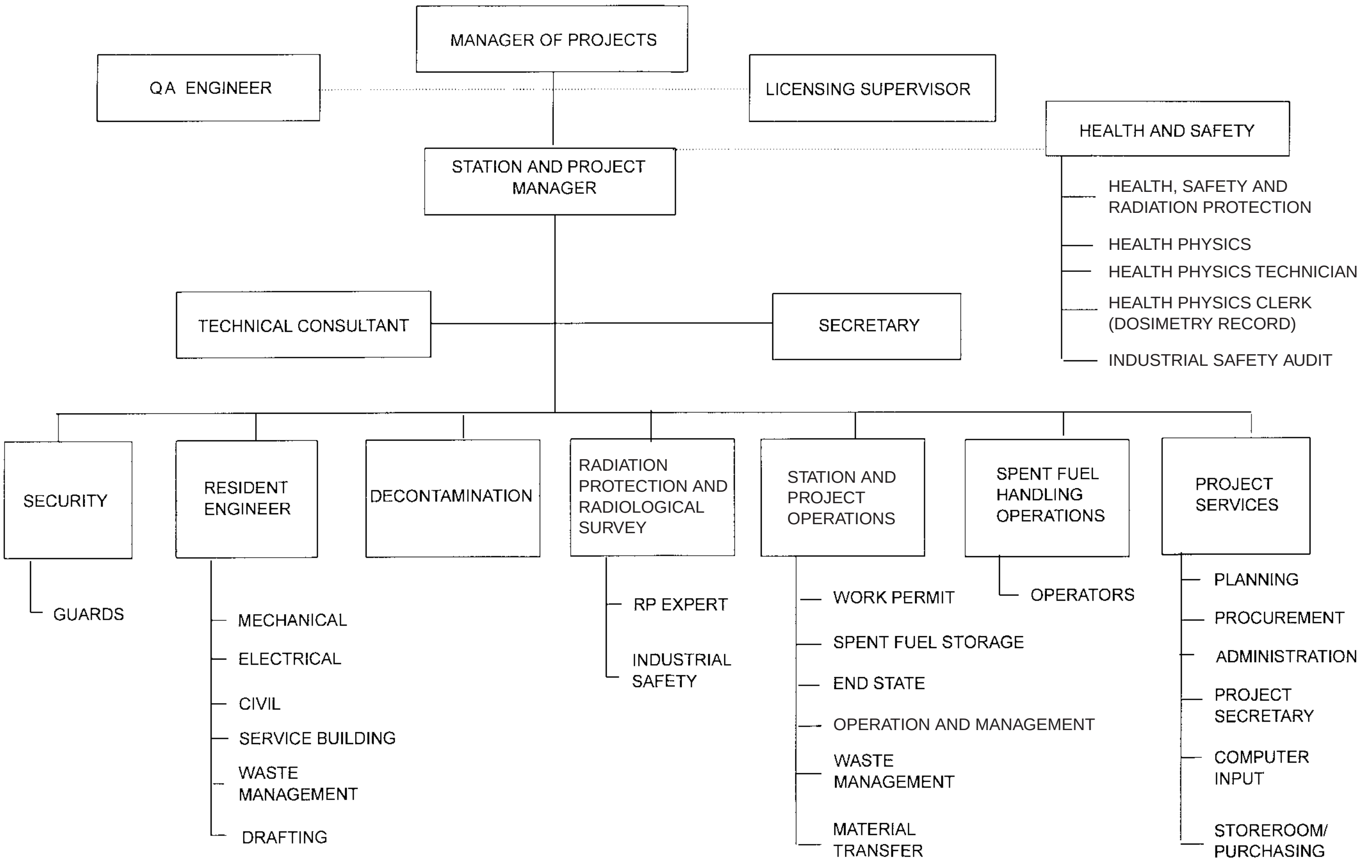

FIG. 1. Gentilly-1 decommissioning project organization chart.

TABLE II: LIST OF DECOMMISSIONING QA REQUIREMENTS

The following decommissioning QA requirements are applicable to the Gentilly-1 project: • List of decommissioning QA requirements • Reparation and control of field instruments • Selection and training of personnel • Identification of area, equipment and system components • Handling and packaging of material • Plant security and visitor control • Emergency procedures • Calibration of measuring and test equipment • Radiation management • Decontamination • Worker protection • Special processes • Identification, operation and maintenance of essential systems • Radiological zones • Post-decommissioning activities • Transport of waste • Waste disposal • Documents/records control

The project team largely consisted of staff of the owner (AECL) and the operator (Hydro Quebec) organizations.

5. QUALITY ASSURANCE

Decommissioning activities conformed to the standards of the Canadian Standards Association (CSA), the Atomic Energy Control Regulations and the Quebec Department of Labour Regulations.

Project specific documents and procedures were developed on the basis of AECL's own policy and procedures, and the requirements of the above standards. These include:

- Engineering quality assurance
- Decommissioning quality assurance
- Licensing
- Health, safety and environmental protection
- Radiation protection.

Engineering QA activities were governed by the CSA Standard N286.2 - Design Quality Assurance Programme. Decommissioning QA was governed by CSA Standard N286.0: Owner's Quality Assurance Programme. A list of the Gentilly-1 Decommissioning QA requirements is included in Table II.

As of June 1984, AECL had a 'possession only license' for Gentilly-1. In September 1985, the Canadian regulatory agency, the Atomic Energy Control Board (AECB), issued to AECL a waste management facility operating licence for the Gentilly-1 spent fuel storage area, thereby permitting on-site dry storage of spent fuel in concrete canisters. A more comprehensive waste management facility operating licence was issued which covers operations of the spent fuel storage area as well as the complete Gentilly-1 site. The current licence is valid for an indefinite period.

Annex A–5

ESTONIA (NUCLEAR FACILITY AT PALDISKI)

1. INTRODUCTION

In the early 1960s, a nuclear facility was constructed for the USSR navy at Paldiski, Estonia. Two scaled submarine mock-ups, each containing full sized nuclear reactors of 70 and 90 MW(th), respectively, were used to train the navy staff in safe operation of submarine nuclear reactor systems.

After Estonia had become independent in 1991, the responsibility for cleanup and decommissioning of the Paldiski site became a subject of negotiations between the Russian Federation and Estonia. As a result, both reactors were defuelled, and the spent fuel was returned to the Russian Federation in October 1994. The reactors were prepared for safe storage by being enclosed in concrete sarcophagi. In 1995, ownership and control of the site were officially transferred to the Republic of Estonia.

2. LEGAL ASPECTS

By the time the Paldiski facilities were taken over, no national legal framework regulating radiation protection and nuclear safety existed in Estonia. However, the Estonian parliament decided to extend the validity of the relevant regulations of the former USSR until they would be replaced by corresponding national acts.

The Estonian Radiation Act was adopted by Parliament in April 1997. Subsequently, a number of lower level legal acts (such as regulations on the issuance of licences for radiation practice, on safe transport of radioactive substances, on radioactive waste management, on exemption criteria, on national dose registry, etc.) have already been approved, and a few more are being elaborated. The latter include an amendment to the existing regulation on radioactive waste management, a regulation on introduction of clearance levels of radioactive materials, etc. At present, there is no specific legal act declaring the national policy for decommissioning of nuclear facilities. Decommissioning projects as such are not mentioned as a licensable activity in the radiation act, which, however, sets out a requirement of application for a licence for radiation practice in the construction, operation and decommissioning of nuclear facilities.

Two regulations on methodical guidelines for implementing environmental impact assessment are also applicable for non-radiological environmental aspects of decommissioning in Estonia. These documents address the important role of the public, in particular the role of local authorities, in the process of environmental impact assessment.

3. ORGANIZATIONS AND INSTITUTIONS INVOLVED IN DECOMMISSIONING

Estonian Radiation Protection Centre (established in January 1996, reporting to the Ministry of the Environment): a regulatory authority responsible for supervising the implementation of the provisions of the radiation act, for issuance of licences for radiation practices, for the maintenance of the national occupational dose registry database, for arranging the environmental radioactivity monitoring and dose assessment, etc.

Occupational Safety Inspection: conventional industrial safety, hazardous substances, asbestos, etc.

Estonian Radioactive Waste Management Establishment, ALARA Ltd. (established in July 1995, reporting to the Ministry of Economic Affairs): an operator organization responsible for managing the Paldiski site and for the development and implementation of the projects related to radioactive waste management, including decommissioning.

Ministry of Social Affairs: responsible for the health surveillance of radiation workers.

4. ORGANIZATION OF ALARA LTD

ALARA Ltd is a fully State owned company reporting to the Ministry of Economic Affairs. The operation and investment costs are funded by the State budget. Currently, ALARA Ltd has a staff of 20 persons; it takes subcontracts for conventional maintenance and construction work.

The organization chart of ALARA Ltd is presented in Fig. 1.

5. SPECIFICS OF DECOMMISSIONING ISSUES IN ESTONIA

To manage the Paldiski site and the associated decommissioning activities, a State owned company, ALARA Ltd., was established by the Estonian Government. Because of its recent creation, ALARA Ltd is still gaining experience in the nuclear field. Furthermore, there are also significant lacunas in information on technical design and operational history of the facility.

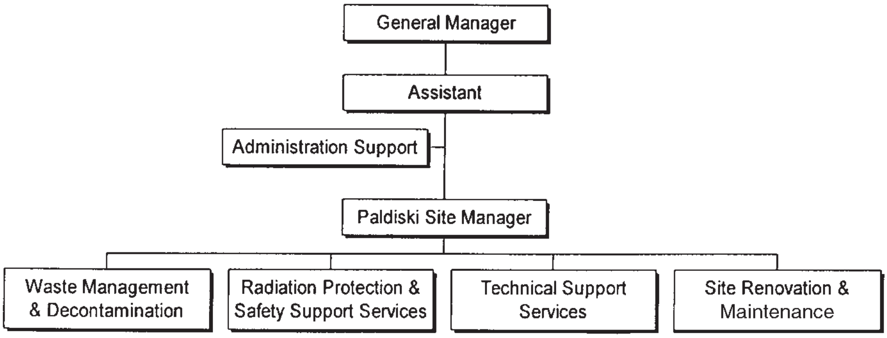

FIG. 1. Organization of ALARA Ltd.

Funding limitations cause problems in the provision of items required for actual work and proper timing of the projects. The same applies to planning, management, quality assurance and to ensuring compliance with the requirements of the Estonian radiological and non-radiological regulations. The shortage of funding also restricts the training of operators and managers in system requirements and in technical requirements for radioactive and non-radioactive waste management.

The Estonian Government has initiated an international campaign aimed at acquiring assistance and support for the management and decommissioning of the Paldiski site. After consultations with different countries and international organizations, in January 1994 a meeting was held in Stockholm, which was the beginning of an active international engagement on the issue of decommissioning the Paldiski facility. At a later meeting, the Paldiski International Expert Reference Group (PIERG) was established. The main objective of founding PIERG was to promote the safe and timely decommissioning of the former Soviet Union Nuclear Training Centre at Paldiski by advising and assisting the parties participating in the decommissioning work on technical, legal, organizational, financial, waste management and radiation protection matters. Since its establishment, PIERG has been acting as the co-ordinating group for international assistance and co-operation projects designated to Estonian authorities in the fields of waste management and decommissioning.

6. THE CONCEPTUAL PALDISKI DECOMMISSIONING PLAN

One of the first tasks of PIERG was to assist the Estonian Government in the planning of decommissioning activities at the site. A conceptual decommissioning plan taking into account both technical and non-technical conditions and constraints was proposed. These conditions and constraints included:

- sealing the submarine reactor compartments within reinforced concrete sarcophagi before the site would be handed over;
- absence of a clear Estonian policy on decommissioning and waste management and lack of relevant legislation;
- shortage of technical and financial resources and significant uncertainties on when these resources would become available (e.g. the problem of a final repository for long lived decommissioning waste).

An essential aspect of design and construction of reactor enclosures is the requirement that eventual dismantling should be facilitated. At Paldiski, the reactor sarcophagi were designed and constructed in order to maximize long term integrity rather than to facilitate early dismantling.

Accordingly, decommissioning based on immediate dismantling and unrestricted site release was considered as non-realistic. However, from a technical and radiological point of view, the task group also proposed that decommissioning activities should be initiated without delay as soon as the resources permit.

An important element in developing a safe enclosure strategy is that physical/radiological surveillance and maintenance requirements should be minimized. From the latter requirements it follows that the extent of radioactive areas should be minimized and a passive configuration should be reached. These options have been clearly addressed in the Paldiski conceptual decommissioning plan. On completion of the decommissioning activities for safe storage, all residual radioactivity would be confined in a stable form at the Paldiski site. A safe storage strategy requires a robust, durable structure for safe containment of radioactive materials for long periods of time. The main technological building housing the two reactor sarcophagi was considered to offer suitable characteristics for long term storage of both reactors and radioactive wastes. Conversion of part of the main technological building into an interim waste storage facility was proposed. This facility would solve the problem of storage of radioactive waste generated during the execution of the 'historical' operational waste conditioning projects as well as of the planned decontamination and decommissioning activities.

The conceptual decommissioning plan proposes a decommissioning strategy for the site to be implemented by Estonia. Works for improvement and further refinement of the decommissioning plan would continue as resources and relevant information would became available. The conceptual decommissioning plan had served to provide a good starting point for the development of a site management plan and a detailed decommissioning plan.

The highest priority in the decommissioning plan is assigned to preventing the spread of radioactive, non-radioactive and hazardous material to the environment as well as to the minimization of waste volume. Treatment of non-radioactive wastes will be co-ordinated with other environmental restoration projects under way on the

Pakri peninsula, where Paldiski is located. Site specific procedures are being established for the treatment, packaging and storage of the radioactive materials. The final waste management plan should be approved in accordance with regulatory requirements imposed by the Estonian regulatory authorities.

7. GENERAL CONSIDERATIONS OF THE DECOMMISSIONING PLAN

The final goal of decommissioning is to remove all radioactive material from the site and to release the site for unrestricted use. Considering the economic aspects and the status of radioactive waste management in Estonia, this can be achieved in two steps:

In the first step, the existing operational waste, contaminated systems, components, building materials, etc., at the site should be concentrated in an interim waste storage facility. During this phase radioactive material from all other buildings at the site should be sorted, conditioned and packaged in suitable containers that could later be used for final disposal.

As the second step, free release of the site could be envisaged if in the future a final repository for radioactive waste were constructed in Estonia.

As a continuation of the conceptual decommissioning plan, a more detailed site management plan was developed. The foreseen activities were divided into three groups: short term (zero to two years), medium term (three to six years) and long term activities. The short term programme included:

- collecting and updating the documentation of the system and buildings, and characterization studies that will be needed for the medium and long term programmes;
- development and implementation of a radiation safety and health physics programme;
- renovation of the site infrastructure and rearrangement of the site for decommissioning purposes: establishment of a centralized radioactive waste management facility and an interim storage capacity for radioactive waste;
- characterization, conditioning and packaging of operational waste in the solid waste storage, liquid waste treatment and liquid waste storage facilities;
- preparation for a feasibility study on a final repository for radioactive waste in Estonia;

The medium term actions to be performed during three to six years should include:

- preparation of technical studies and reports, including cost estimates and time schedules, for individual dismantling and decommissioning projects for approval and for financing of these projects;
- implementation of individual projects on decontamination and dismantling of specific auxiliary facilities;
- a study on the technical evaluation of management options for the two reactor sarcophagi.

The long term programme consists mostly of normal operation of the interim waste storage facility and the execution of a project on decommissioning of two submarine reactors.

The time schedule of the site management plan and unrestricted site release is uncertain, as it depends on the availability of funding for the work foreseen.

8. CONCLUSIONS

The Estonian decommissioning situation described above creates a need for improvement and development in the organizational and management aspects of decommissioning, which should include:

- definition of a national policy and strategy on decommissioning and radioactive waste management, including the elaboration of legal framework and administrative provisions and identifying authorities responsible for the policy;
- allocation of appropriate financial resources.

Progress has been achieved in recent years in setting up a national organization and acquiring expertise in the field of decommissioning. Estonia has received international support through co-operation projects and programmes on a bilateral level and with international organizations.

Annex A–6

GERMANY (GREIFSWALD AND RHEINSBERG NPPS)

1. INTRODUCTION

On the Greifswald site, eight units of WWER 440 reactors are located as well as several facilities to handle fuel and radwaste. Immediately after the unification of Germany in 1989, the operating units 1 to 5 were shut down, and the construction work at units 6 to 8 was ceased. On the Rheinsberg site, the former GDR's first operating nuclear power station (WWER 2 prototype) was shut down, as well. After serious considerations on refitting and restarting of some reactors, the decision was taken to decommission these Russian designed reactors. Thus, the licensee (Energiewerke Nord GmbH-EWN) is faced with the world's largest nuclear power station decommissioning project. On both sites, the decommissioning work started in 1995. The following description is based on the official project handbook of EWN.

2. POST OPERATION ACTIVITIES

The operational organization is still necessary in order to defuel all units as a precondition for any dismantling activity. This is performed in accordance with the rules of the official operational handbook, which is valid until all units are free of nuclear fuel. After shutdown, several phases of post-operational activities can be differentiated:

- **Post-operation**

No energy production, many systems still in operation (cooling systems, ventilation system), fuel elements still in the reactor and cooling pond of a unit still active.

- **Reduced post-operation**

No fuel elements in the reactor, but still in the cooling pond. The necessary handling of fuel elements — storage and transport activities — can be performed safely with a reduced number of systems.

- **Remaining operation**

The units are free of fuel, only a small amount is stored in CASTOR casks (dry transport and storage casks) inside the units. The cooling systems are no longer needed. The remaining systems are related to conditioning, packaging and transport of operational waste for interim storage or disposal.

- **Dismantling operation**

The units are free of any fuel and operational waste so that dismantling can be performed without major restrictions. The remaining systems are related to the safe enclosure of the still present radioactivity and to the safe execution of all dismantling work.

3. PROJECT STRUCTURE AND ORGANIZATION

The task of EWN is the 'decommissioning of the NPPs of Greifswald and Rheinsberg' with its own personnel as far as this is possible, at minimum cost, and as quickly as possible. Furthermore, the site is to be prepared for restoration and reuse in the future. Because of its size and complexity, this enterprise is called a 'megaproject'.

3.1. PRINCIPLES OF A RELATIONAL PROJECT STRUCTURE

The project is time limited, with a clearly defined content and objective, and cannot be repeated. Accordingly, there is a wealth of single measures, which are unique themselves and time limited as well. To order all these measures, they have to be integrated into a hierarchic structure.

The use of a relational database system allows every single measure to be subordinated to different and independent structures. In this way, it is possible to make approaches from different points of view at any time. The project structure plan for the megaproject 'decommissioning of the NPPs of Greifswald and Rheinsberg' contains the following structures:

- Basic handling structure
- Responsibility structure
- Object structure
- Work category structure
- Phase structure.

Priority was given to the basic steps of handling structure execution derived from the sequences of the decommissioning work (Fig. 1).

3.2. Basic handling structure

The megaproject ‘decommissioning of NPPs of Greifswald and Rheinsberg’ is divided into six ‘projects’ as follows:

- Project 1: Dismantling of the NPPs on the Greifswald site
- Project 2: Dismantling of the NPP on the Rheinsberg site
- Project 3: Refurbishment
- Project 4: Erection and operation of the Interim Storage North (ISN)
- Project 5: Waste management
- Project 6: Site remediation and reuse.

Responsibility for these projects rests with the project management. The project managers are responsible for the definition, organization, costs and the timely execution of their activities. The organization and management structure is performed according to these projects, and the existing operational organization of EWN has to

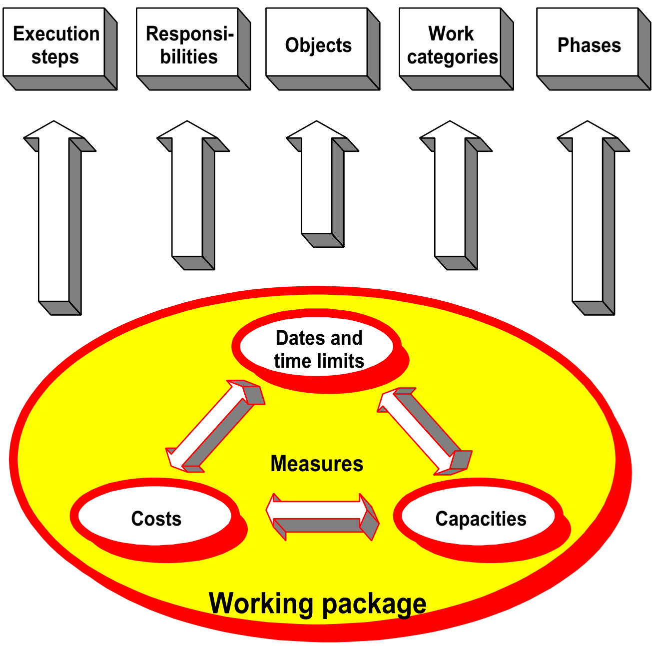

FIG. 1. Relational project structure.

be converted step by step into the project structure. Eventually, in the dismantling operation phase as described above, every work and activity will be steered and controlled by the project management. The ‘operational’ structure is no longer needed.

On the basis of an analysis of the company development and personnel strategy, a technical concept was worked out and the project was broken down to working package level. The basic handling structure is the primary structure, which is directly related to the step by step execution of the decommissioning activities. It comprises the following levels:

Megaproject is the sum of all projects aimed at decommissioning the NPPs of Greifswald and Rheinsberg until the site has reached a state which allows further use.

Projects are clearly defined parts of the megaproject, with a main objective.

Part projects are parts of the project to reach the objective of the project, which has a definite objective and clearly defined corresponding measures.

Programmes are clearly defined parts of the part project, with a definite part objective, for which additional criteria, as e.g. points of execution or organization, may be used.

Working packages are units of planning and execution work with complete content definition, measures, costs, capacities, interfaces, etc., which are treated as a unified whole in the frame of the time schedule, the budget schedule and the personnel plan.

Further broken down levels for the execution of the working packages are defined under the same aspects and treated accordingly:

Activities are clearly defined parts of the working packages, if the working package does not fulfil the criteria of the in-depth structuring of that project.

Actions are defined subunits of an activity that are not considered in the central cost calculation.

Tasks are defined subunits of an action, as e.g. to-do lists.

The working packages are at the centre of all planning and controlling work, in the framework of the basic handling structure of the project work. At this level, top and bottom control as well as estimation and calculation converge, as is depicted in Fig. 2.

4. PROJECT MANAGEMENT AND INFORMATION SYSTEM

For the project management tasks, a sophisticated software has been developed in the form of a relational database system, allowing the handling and treatment of all

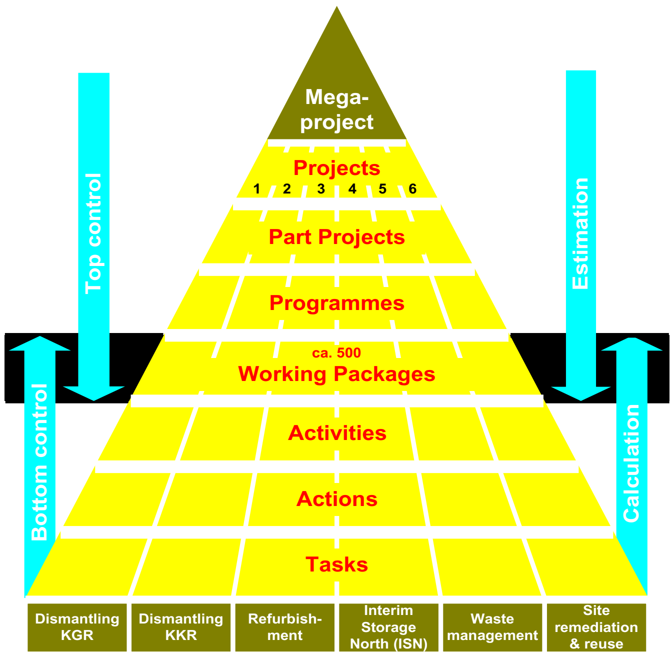

FIG. 2. Basic handling structure.

necessary data. In this way, in addition to the normal project control tasks (conventional software), it is possible to perform technical planning, work preparation planning, tracking and control of dismantled material and radioactive waste. Actual data, e.g. from the dismantling operations or the mass flow, are registered, evaluated and fed back into the system (Fig. 3).

5. LICENSING PROCEDURE

For planning security, the licensing procedure for a decommissioning project in Germany has to be initiated by the applicant at the earliest possible date, owing to the complexity of this procedure and the number of stakeholders. After the application, the licensing authority of the concerned Federal State usually involves authorized experts and other concerned authorities. If it is necessary according to German atomic law, the authority makes the application available to the public.

In addition to the atomic law and the subordinated ordinances, the basis for the decisions of the licensing authority is the recommendations of the Radiation Protection and the Reactor Safety Commissions. The Federal Ministry of Reactor

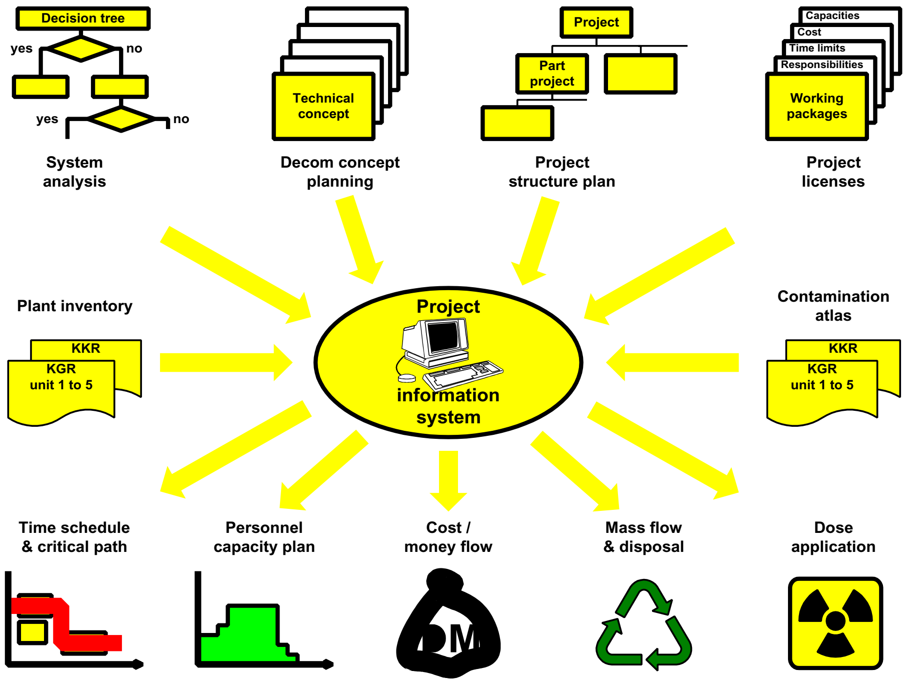

FIG. 3. Project management and information system.

Safety and Environment has to be informed and has the right to advise the licensing authority.

The overall procedure may last from a few months — a rare case — up to several years. In the case of this project, the first application was made in 1994, and the according licence was granted in June 1995. In total, seven main applications for decommissioning are foreseen, and at present five have been granted. The stakeholders in the licensing procedure and their interactions are shown in Fig. 4.

6. CONCLUDING RECOMMENDATIONS

On the basis of the decommissioning experiences of EWN, the following recommendations can be made:

- Before starting any decommissioning activity, a complete analysis of the present state and the future perspectives has to be made taking into account all site specific boundary conditions, the company objectives, as well as social and psychological aspects.

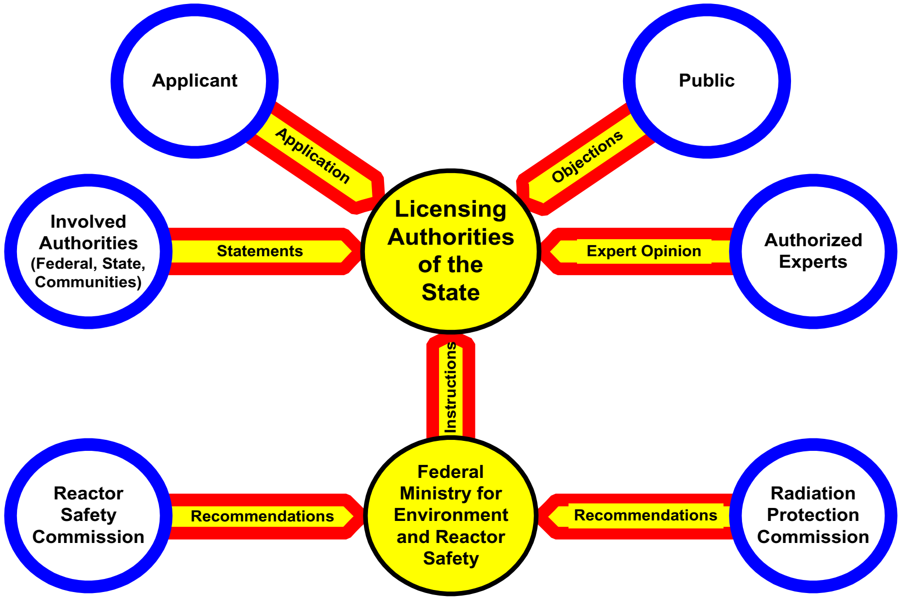

FIG. 4. Stakeholders in the licensing procedure according to German atomic law.

- After clarification of the situation a technical concept has to be established, which, together with the system analysis, is the basis for the implementation of a project structure to gradually replace the existing operational structure. Normally, a social plan has to be worked out.
- To avoid delays, the licensing procedure has to be initiated as soon as possible. For large projects it is recommended to apply a split licensing procedure. In this way, a constant workload from applicant and authority can be obtained and thus a smooth project is achieved. The first application should comprise all necessary activities for the start of the decommissioning project. Close co-operation with the licensing authorities and the authorized experts is mandatory for a successful project at all levels.
- Inventorization of the overall plant has to be started as soon as possible. Mass inventory, setting-up of a dose rate/contamination atlas and extensive sampling to determine the nuclide vectors have to be carried out carefully. This is mandatory for preplanning the mass and activity flows as well as the necessary treatment facilities and devices. All logistics, including buffer storage, have to be prepared very carefully.
- As an essential tool for the project management, a relational database system is recommended to be in place, especially for project control (time limits, cost) and mass flow supervision.

Annex A–7

ITALY (DECOMMISSIONING OF ITALY'S NPPS)

1. INTRODUCTION

In Italy, four NPPs of different kind have been operated for several decades with a high degree of safety and efficiency: two BWRs (Garigliano, Caorso), a PWR (Trino) and a gas graphite reactor (Latina). In 1998 the Italian Government decided to stop nuclear energy production.

Since then the nuclear branch of the utility's (ENEL) production department has started the decommissioning activities, with particular emphasis on the conditioning of operational wastes.

Recently, according to a new company policy, this nuclear branch has been reorganized into a new integrated structure, SGN (Nuclear Plant Management), in charge of:

- the overall strategy for the decommissioning project in the framework of the company planning;
- the decommissioning of the four NPPs according to the approval released by the regulatory body;
- the waste treatment and characterization;
- the closure of the fuel cycle;
- the offering of engineering services to the external market.

The decommissioning strategy being followed at the moment by SGN is that of safe storage. As a consequence, the main SGN target is decommissioning planning and implementation, in particular the activities to realize the 'passive safe storage condition' of NPPs, spent fuel disposal, waste removal and conditioning, and the sale of fresh fuel. To fulfil its mission, SGN can rely on funds established by the company, as well as on a staff of 500 persons.

The decommissioning activities will be developed according to an integrated strategy which takes into account several aspects such as regulations, procedures, availability of necessary infrastructures and financial resources.

The SGN decommissioning policy underlines the opportunity to minimize the related costs and to do business in an international scenario.

2. ORGANIZATIONAL STRUCTURE

SGN has been organized (Fig. 1) into six main central departments and three territorial units; in addition, there is a staff position of business development.

The three territorial units are strictly connected to the central departments that should control and give guidance to ensure an organic development of the activities.

Business development works together with the above mentioned departments as they share the same market strategy and the same resources.

The six central departments consist of:

- Administration and budget
- Human resources and services
- Engineering and technologies
- Legal department
- Health physics and safety
- Decommissioning and fuel operations.

The administration and budget department is in charge of:

- budget
- administration
- accounting and balance sheet
- procurement
- management of some services and contracts to eastern European countries.

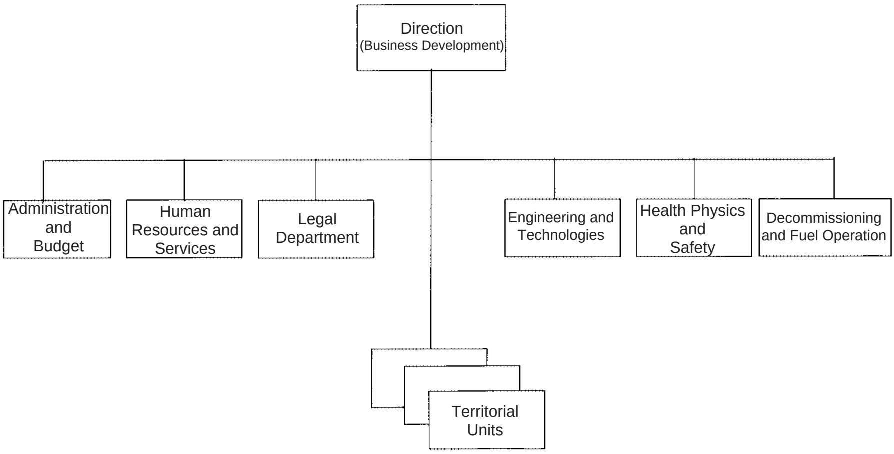

FIG. 1. SGN organizational structure.

The human resources and services department is in charge of:

- general business and services
- insurances
- resources development and planning
- organization
- industrial relations
- personnel administration
- personnel statistical–economical analysis.

The legal department is in charge of:

- legal advice
- contracts transactions together with the other departments and territorial units
- litigation procedure
- the legislative follow-up and interpretation.

The engineering and technologies department is in charge of:

- strategic analysis and technical–economical studies for the optimization of the decommissioning process
- decommissioning costs evaluation
- activities related to the unreprocessed spent fuel
- engineering for decommissioning
- development of technologies for decommissioning and conditioning of radioactive waste
- specific projects
- co-ordination of the technical codes and standards development
- fund raising.

The health physics and safety department is in charge of:

- health physics
- safety
- QA.

The decommissioning and fuel operations department is in charge of:

- guidance and control of the decommissioning programme implementation, including the appropriate support
- detailed planning of the NPP decommissioning

- management of fresh and spent unreprocessed fuel
- reprocessing services management
- co-ordination activities on radioactive waste treatment, conditioning and storage
- relations with institutions, local authorities, national regulatory body and international organizations
- licensing.

The business development position is in charge of:

- national and international market analysis
- business qualification (demanded products and possible revenues)
- national and international alliances
- identification of market chances
- co-ordination of the relations with national, international and European clients for order acquisition
- identification, in collaboration with SGN departments, of qualifications, expertise, technologies and assets as needed
- co-ordination of participation in call for bids
- definition of tender price.

The three territorial units (Trino, Caorso, Latina–Garigliano) are in charge of:

- NPP management under the different configurations, according to unitary schemes
- participation in engineering activities, in the definition of detailed working programmes and in identifying the needed resources
- implementation of the operational activities with internal and/or external resources
- final assessment of the components, systems and structures in the passive safe storage condition.

During the passive safe storage preparation, the activities are mainly devoted to:

- NPP operational management
- Activities for decommissioning.

3. DECOMMISSIONING ACTIVITY

SGN decommissioning strategy (Fig. 2) is based on safe storage, which has been adopted in accordance with the regulatory body. At the moment, this is the only possible strategy which can assure an appropriate use of the resources available in Italy.

SGN decommissioning strategy includes six main phases:

- activity for operation termination
- licence change
- decontamination and safe storage of systems and structures
- passive safe storage conditioning
- final dismantling of the activated systems and structures
- site release.

The first phase is related to waste management, fuel removal from the nuclear reactor and NPP characterization. The second phase is characterized by the definition of a general decommissioning strategy and by the revision of licence conditions, technical specifications and emergency plans. This revision allows a reduction of the NPP staff and better utilization of the newly available specialized people. After approval of the general decommissioning strategy, the detailed projects will be developed and give the guidelines for work execution. Decontamination activities can allow the release of some components and buildings, according to the clearance limits for such materials. The remaining radioactive wastes are conditioned and then sent to a repository. If the repository is not available the radioactive wastes will be stored in a suitable NPP building. Buildings and systems which are not decontaminated should be drained and isolated from the environment in order to avoid any possible radioactive release risk. At the end of this third phase, some NPP buildings should be released. From the date of the NPP final shutdown, the final dismantling activity should be delayed for 30 to 40 years in order to reduce both the doses to the workers and the total volume of the radioactive waste. Of course, the support by robotic and other technologies can shorten this period; however, as in Italy no national repository is available so far, there is no reason for prompt dismantling.

Another aspect of safe storage strategy should be taken into account: the passive safe storage period should allow the necessary funds to be acquired for realizing the dismantling activities. This final dismantling phase is strictly connected to regulatory requirements and, in general, to external interactions. It includes the dismantling of the remaining activated systems and structures. According to the clearance limits, the waste can again be released, or conditioned and stored.

The final step of the decommissioning process is represented by the site release, in which a final radiological survey will allow the NPP buildings to be considered as an ordinary industrial relic. The regulatory body will give approval to the final radiological survey procedures and results.

A technical and economic analysis of the above mentioned strategy is currently being performed, together with an external advisor, in order to update the base cost estimates. This analysis will also consider the technical–economic consequences of any change in the strategy.

FIG. 2. SGN decommissioning strategy.

Annex A–8

JAPAN (JPDR DECOMMISSIONING)

1. INTRODUCTION

As of April 1999, there are 52 nuclear power plants operating in Japan, producing more than 30% (42 000 MW(e)) of the total power generation. However, it is expected that ten nuclear power plants will have operated for more than 30 years by the year 2005. So far, one of the oldest nuclear power plants, the Tokai power station (MAGNOX, 160 MW(e)), has been permanently shut down; it is to be decommissioned to green field conditions in the near future [1]. Since decommissioning of nuclear facilities is one of the most important issues in the development of nuclear energy, studies on decommissioning nuclear power plants have been conducted continuously in Government organizations and in the private sector. In 1997, the study committee for nuclear power plant decommissioning reported the results of a review on decommissioning technology to the nuclear subcommittee of the Ministry of International Trade and Industry's (MITI) Advisory Committee for Energy. It emphasized the necessity of a systematic approach and of waste management systems for decommissioning nuclear power plants, taking into account cost effectiveness and safety. On the basis of this report, the regulatory framework for decommissioning nuclear power plants, including waste disposal methods and clearance levels, is being discussed in Government organizations.

In addition to nuclear power plants, a number of prototype and test nuclear facilities have been constructed for the development of nuclear energy and its utilization in research organizations. Some of the nuclear facilities constructed in the early days of nuclear energy development have fulfilled their initial purpose and await decommissioning. In the Japan Atomic Energy Research Institute (JAERI), four major nuclear facilities, including one prototype nuclear power plant, have already been decommissioned; two decommissioning projects, research reactor JRR-2 and reprocessing test facility JRTF, are under way.

The Japan Power Demonstration Reactor (JPDR) Decommissioning Programme was a flagship project to demonstrate the possibility of decommissioning a nuclear power plant by using present technologies; it was completed in March 1996 and recovered green field conditions in JAERI [2]. The JPDR decommissioning programme may be a typical example for reviewing the decommissioning technology, dismantling activities and organization and management aspects for future projects. Therefore, this report describes the Japanese approach to decommissioning nuclear power plants in terms of organization and management, focusing on the JPDR decommissioning programme.

2. BACKGROUND

In 1982, the Atomic Energy Commission (AEC) published the basic policy for decommissioning nuclear power plants as a part of the long-term programme for development and utilization of nuclear energy [3]. The long-term programme has been revised every several years; the basic policy for decommissioning nuclear power plants is unchanged in the recent version. It states that, as a rule, the nuclear power plant should be dismantled and removed as soon as possible after its shutdown and the site should be effectively used for the next nuclear power plant. It also describes that technologies needed for future decommissioning of commercial nuclear power plants should be developed through the JPDR and the JRTF (JAERI reprocessing test facility) decommissioning programmes.

To establish the practical approach and the funding system for decommissioning commercial nuclear power plants, the study committee for nuclear power plant decommissioning studied the measures to be taken in decommissioning nuclear power plants. It reported the standardized decommissioning procedures and estimation of decommissioning costs, with waste arising and radiation exposure of workers, indicating the benefit of dismantling a facility within five to ten years of mothballing. The decommissioning fund was established on the bases of this study; it is included in the electricity charges.

The study committee for nuclear plant decommissioning resumed its activities in March 1996, after a break of almost 11 years. The committee reviewed the present status and issues of the nuclear power plant decommissioning regulatory framework, waste management systems, etc., in Japan. The major conclusions of the study reported to the Nuclear Subcommittee of MITI's Advisory Committee for Energy are as follows: no technical problem remains to be solved in decommissioning nuclear power plants, detailed regulatory procedures should be established, and the measures of decommissioning waste disposal should be prepared practically for the next decommissioning programme.

The problems of waste management in decommissioning nuclear power plants have also been studied by the subcommittee of the Nuclear Safety Commission. The proposal of clearance levels for waste in decommissioning and the estimation of waste disposal costs were set forth as an interim report in 1998.

3. JPDR DECOMMISSIONING PROGRAMME

3.1. JPDR

The JPDR is a BWR type (45 MW(th)) demonstration reactor. For the first time in Japan, it started to generate electricity in October 1963. In 1972, the power was increased to 90 MW(th) in order to increase the neutron irradiation capability. The JPDR was shut down in March 1976, because of several problems such as cracking on the nozzle of the in-core monitor tubes, a failure of the control rod drive mechanism and other complications. As of April 1988, the residual radioactive inventory in the JPDR is estimated to be approximately 130 TBq. Almost all radioactive inventory (99.9%) remains in the reactor internals, the reactor pressure vessel (RPV) and the biological shield concrete.

3.2. JPDR DISMANTLING ACTIVITIES

After the five years of study of decommissioning technologies, the actual dismantling of the JPDR facility began in December 1986, using advanced techniques [4]. The objectives of dismantling the JPDR were:

- to demonstrate the techniques developed in the R&D phase;
- to gain experience in dismantling activities; and
- to establish a decommissioning database, for future decommissioning of commercial nuclear power plants.

Primary considerations for the dismantling work were the safety of workers and the prevention of release of radioactive materials into the environment. A local ventilation system and underwater dismantling machines operated by remote handling were applied to the dismantling activities in order to minimize the workers' exposure to radiation, while the building walls were used as a confinement boundary for the release of radioactive materials. The dismantling schedule made in advance showed that the critical path was strongly related to dismantling highly radioactive components such as reactor internals, the reactor pressure vessel (RPV) and the biological shield. Efforts were therefore made to dismantle those core components and structures that contained relatively high radioactivity during its operation. The dismantling activities were briefly described as follows [5]:

The reactor internals were removed by an underwater plasma arc saw cutting system. In most cases, the plasma torch was operated by a mast type manipulator. First, all reactor internals were removed from the RPV wall and the cut pieces were then transferred under water to the spent fuel storage pool. The RPV was dismantled by the underwater arc saw cutting system after the piping connected to it had been removed. The top flange portion of the RPV body was cut vertically into nine pieces. The other part was cut into eight horizontal and nine vertical pieces. Three techniques were applied to the demolition of the biological shield to verify and compare the technologies developed. The projected part of the biological shield was demolished by using both diamond sawing/coring and abrasive water jet cutting techniques. A controlled blasting technique was applied to the rest, which was only slightly activated. The extremely low level radioactive waste arising from the demolition of the biological shield and the removal of building surfaces were disposed of into a near surface disposal facility as a demonstration test to verify the safety of the simplified near surface disposal on the JAERI's site.

In parallel with the remote dismantling work, relatively low level radioactive components in other buildings such as the turbine and radioactive waste treatment buildings were dismantled by hand. After all components had been removed, the inner surfaces at the building were decontaminated and the radioactivity was surveyed to confirm that there were no artificial radioactive nuclides remaining in the buildings. These were the final steps before releasing the facility into an uncontrolled area. The building structures were then demolished by conventional tools up to green field conditions.

Table I outlines the JPDR dismantling activities.

3.3. MANAGEMENT FOR DISMANTLING ACTIVITIES

3.3.1. Safety assurance

At the beginning of the JPDR dismantling activities, the Nuclear Safety Commission (NSC) published the report 'Philosophy of Safety Assurance during Reactor Dismantlement — Dismantling JPDR' [6]. This report stated guidelines to ensure the safety of the JPDR dismantling activities. The enforcement plan of the

TABLE I. OUTLINE OF JPDR DISMANTLING ACTIVITIES

Dismantling project overview	
Project period	December 1986 – March 1996
Project cost	23 billion yen (including R&D)
Waste arising	3770 t (radioactive)
Worker dose	306 man–mSv
Project characteristics	
Demonstration	Application of developed techniques
Dismantling activities	Collection of project management data
Waste storage (radioactive)	Storage of waste in storage facility
Waste disposal (low level)	Near surface burial at the JAERI site

JPDR dismantling was made on the basis of this report, and it was submitted to the Science and Technology Agency (STA) in July 1986. After NSC's authorization of this plan, JPDR dismantling activities in JAERI started in December 1986. The key principles of the enforcement plan were to ensure the safety of workers and to prevent radioactive materials from being released.

The JPDR facility was dismantled on the basis of the key principles. In addition, a quality assurance (QA) committee was organized by experts in JAERI. The main tasks of the QA committee were to check up the enforcement plan of each dismantling activity and to review the report to be submitted to the STA. Especially in applying the new technology to the dismantling activities, the activity plan was examined in detail by the QA committee, with regard to the safety of workers and efficient work procedures.

The implementation of the dismantling activities was basically regulated by the 'operational safety rules' prepared for the JPDR facility. The operational safety rules are based on the nuclear reactor regulations law for each nuclear facility to be operated safely. The operational safety rules for the JPDR facility were reformed with progressing dismantling activities, after negotiations with the regulatory body.

3.3.2. Organization

The JPDR decommissioning programme was basically carried out by four divisions and one laboratory:

- the JPDR administration division,
- the decommissioning programme co-ordination division,
- the reactor decommissioning operation division,
- the decommissioning waste management division, and
- the decommissioning technology laboratory.

In the JPDR decommissioning programme, JAERI contracted with several companies to implement the dismantling activities. Since the budget of the JPDR decommissioning programme was decided on an annual basis, the contract was formally set up every year, i.e. the dismantling activities started at the first of April every year and finished by the end of March, as a general rule. Before the dismantling activities were carried out, a report describing the details of each dismantling activity was prepared by the staff in both the decommissioning programme co-ordination and the reactor decommissioning operation divisions. The report was submitted to the STA for authorization of the work plan at each step of the dismantling activities, after having been checked by the QA committee. The report contained work specifications and schedules, characteristics of the components to be dismantled, waste arising, etc. The company contracted to the work also prepared a detailed work implementation

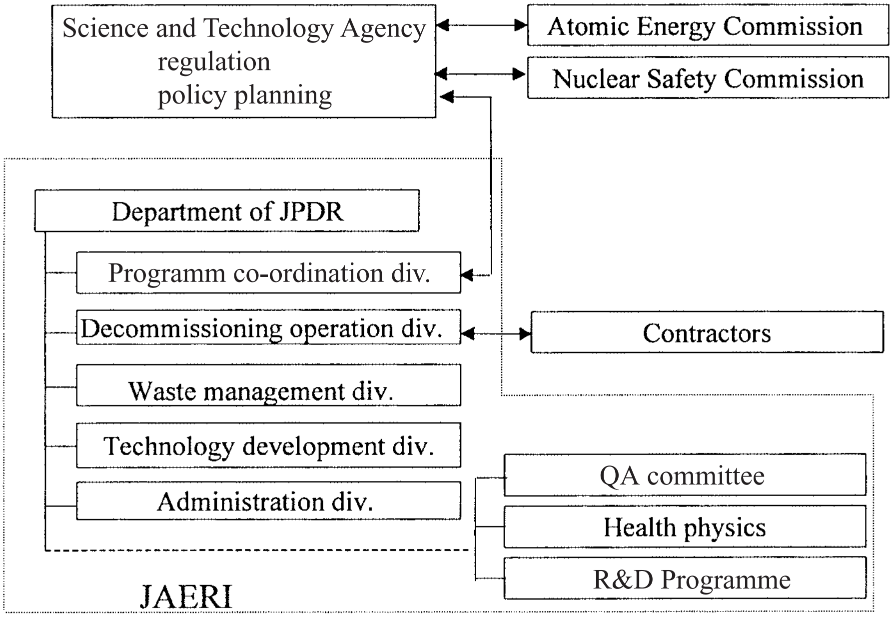

FIG. 1. Project management structure for decommissioning JPDR.

plan based on the report submitted to the STA. The dismantling activities were supervised by the staff of the reactor decommissioning operation division in JAERI. After each process of the dismantling activities had been accomplished, the results of the work were also reported to the STA and examined for compliance with the plan submitted before. STA inspectors visited the JPDR facility to observe the dismantling activities and check the records at the time of all major work activities. The decommissioning programme co-ordination division played a role in coping with matters relating to STA.

The decommissioning waste management division and the decommissioning technology laboratory were mainly in charge of waste management, and data collection and analysis, respectively. All data collected in dismantling activities were transferred to the decommissioning technology laboratory to be accumulated in the database and for dismantling activities to be analysed. The data and the analysed results were provided to the decommissioning programme co-ordination and reactor decommissioning operation divisions for preparing the next dismantling plan and reporting to the STA.

Figure 1 shows the organizational structures of JPDR decommissioning programme.

3.3.3. *Radiation protection control*

Radiation protection control was one of most important issues in the programme. The dose equivalent rate and the radioactive concentration were measured daily and reported to the related divisions by health physicists. Each work plan was made on the basis of this measurement, and work areas were classified into various categories. For example, radioactive contamination was classified into three groups: C-1 (less than 4 Bq/cm^2), C-2 (4 to 40 Bq/cm^2) and C-3 (more than 40 Bq/cm^2). The work conditions, such as respiratory protection and personal protective clothing, were then determined according to this categorization. Data on radiological safety such as dose equivalent rate, radioactive contamination and radioactive nuclide concentration in air were measured periodically in the dismantling work areas. The categorization in the work areas was changed as dismantling activities were accomplished, and the method of dismantling components was sometimes reformed as a result of considerations of safety of the workers and efficient work accomplishment. The workers' exposure to radiation was also measured daily by alarm pocket dosimeters; it will be described later.

3.3.4. *Waste management*

At an early stage of the planning of dismantling activities, the characteristics of decommissioning waste were evaluated as a result of calculations and measurements. More than 4000 samples were taken to evaluate the amount of radioactive contamination in the whole JPDR facility. A total amount of 30 000 t of solid waste, including approximately 4000 t of low level radioactive waste, were expected to be produced in dismantling the JPDR facility. In the actual dismantling work, the dismantled components were classified into four levels (or into more detailed levels, in some cases), on the basis of on-site radioactivity measurements. According to their radiation levels, the components were put into 200 L drums, steel containers (1 or 3 m^3), or shielded containers. In the final step where the building was released into an uncontrolled area, the radiological characterization data were specially utilized to define zones of non-contaminated areas or to classify contamination levels. Decontamination and radioactivity confirmation surveys were conducted on the basis of the classification data.

In addition to solid waste, gaseous and liquid wastes were also produced as a result of the dismantling activities. Gaseous waste was filtered and exhausted through the stack, after the radiation level had been confirmed to be lower than 3 Bq/m^3. Liquid waste was treated by the water treatment systems, which had been used during the operation of JPDR. After confirming that its radioactivity had been found to be lower than 4×10^{-1} Bq/cm^3, the waste was diluted with water so as to reach one hundredth of its radioactivity and then discharged into the Pacific Ocean.

The amount of waste estimated was verified by comparing it with the actual data associated with each radiation level. A total of 24 400 t of waste, including 3770 t of radioactive waste, were produced from the JPDR dismantling activities. The estimate was compared with the actual waste arising in different categories, for example, radioactivity level by radioactivity level or building by building. It was found that the estimate was almost the same as the actual waste arising within an error of 15%, except for the waste produced by building surface decontamination. Detailed measurements of radioactivity on building surfaces resulted in the reduction of waste, compared to the original estimate, by removing contaminated layers from building surfaces.

4. DATA COLLECTION AND ANALYSIS

4.1. DATA COLLECTION AND RETRIEVAL SYSTEMS

Information on the JPDR dismantling activities was collected and accumulated in the decommissioning database. This database was used for:

- managing on-going JPDR dismantling activities,
- verifying the code systems for management of reactor decommissioning (COSMARD) [7], and
- planning future decommissioning of commercial nuclear power reactors.

The data were collected on data collection and retrieval systems which made use of the JAERI mainframe (FACOM-M780) and minicomputers. In addition, information on machine performance and operability was also collected when newly developed decommissioning techniques were applied to dismantling activities.

The JPDR dismantling data were basically grouped into three categories: radiation control dismantling operations and waste management. The radiation control data, including working hours and external dose to workers, were collected by using magnetic identification cards and pocket dosimeters. When passing through the gate of the radiation control area, workers were required to keep records of entering/exiting times and external doses by inserting each worker’s magnetic card and pocket dosimeter into a magnetic reader connected to the minicomputer. The other data were collected in the form of descriptions by the workers’ supervisors. The descriptions were submitted daily to the data collection staff in the systems engineering group. The other data, such as machine performance and unexpected occurrences, were stored as a form of documentation. The major items for data collection are listed in Table II.

TABLE II. DATA COLLECTION ITEMS

Radiation control
• Record of workers entering/exiting controlled areas: time, identification number, alarm pocket dosimeter number, etc.
• Worker exposure: worker exposure, identification number, work permission number, etc.
• Environment of working area: work permission No., contamination, dust, dose rate, date of measurement, etc.
Dismantling activities
• Duration of work dates of start and completion, etc.
• Workforce dismantling activity, person–days, number of workers, etc.
• Utility consumption of electricity, gases, water, etc.
• Unexpected occurrences: date, description of the occurrence, correction, etc.
Waste management
• Waste source, date, material, weight, etc.
• Container type, numbers, radiation levels, radioactivity, dose rate, surface contamination, etc.
• Storage and transportation source, date, treatment (solidification, immobilization of surface contamination), etc.

4.2. USE OF DATA FOR PROJECT MANAGEMENT

The data collected during the dismantling activities were used to manage the JPDR dismantling work. As to the radiation control data, cumulative dose and other information, for example, dates of medical examinations, were checked for compliance with the regulations. When the collective dose itemized by a work permission number exceeded a designed value, the reason was analysed. The results of the analysis were used to modify the plan of other dismantling activities, if necessary. With regard to waste management data, the dismantled components were basically managed by linking them to containers. Each container was identified by a designation number which, in turn, could provide the following information: source and quantity of waste, date of transport and storage, radioactivity level, processing method, etc. As was described before, the data on project management, such as waste arising, manpower expenditure and workers' exposure to radiation were analysed and reported as a periodical documentation.

5. LESSONS LEARNED ON PROJECT MANAGEMENT

The JPDR decommissioning programme was the first trial to dismantle a large scale nuclear facility in Japan. Neither a regulatory framework nor experience on decommissioning nuclear facilities existed at the initial stage of the JPDR decommissioning programme. The organizational structures had to be transferred from the operation and maintenance part to the decommissioning programme within the same department. In addition, since the activities at all stages were regulated by the operational safety rules prepared for the JPDR facility, it was necessary to revise these operational safety rules during the transition of the facility. Organization and management of the JPDR decommissioning programme were characterized by these situations. The lessons learnt on the management of decommissioning activities are as follows:

- The dismantling work was well managed in order to minimize the workers' exposure to radiation. This was possible owing to precise estimations of the radioactive inventory and daily measurement of the dose rate in the work areas.
- The dismantling work was completed on schedule and with no serious problems. Detailed planning of work activities was attributed to the success of the dismantling work. The quality assurance programme played an important role in the check-up of the worker's safety.
- All radioactive waste was stored in the waste storage facility at JAERI's site, except for near surface disposal of very low level concrete waste. Measures for minimizing the volume of radioactive waste should be considered, and adequate treatment of secondary products such as slurry and abrasives was necessary to reduce waste arising.
- The staff engaged in the operation and maintenance of the JPDR facility played an important role in the decommissioning stage as well, because their knowledge of the facility was useful for detailed planning and implementation of dismantling activities.
- The record and the past history were well utilized for dismantling and for the final step to unrestricted release of the facilities. It will be necessary to maintain the record relating to the operation of the facilities.
- A well devised staff disposition plan brought about efficient dismantling activities. The organizational structures should be revised periodically to enable efficient staff disposition in the process of the dismantling activities.

6. CONCLUDING REMARKS

The JPDR decommissioning programme started in April 1981, with the intention to reach green field conditions. Various decommissioning technologies were developed, not only in order to dismantle the JPDR but also to demonstrate their usefulness in future decommissioning of commercial power plants. The actual dismantling activities were conducted from 1986 to 1996, and the JPDR decommissioning programme was completed successfully without any serious problems. However, inflexible organizational structures sometimes resulted in inefficiency in coping with the project, especially in the transition phase from operation and maintenance to the actual dismantling stage.

In the dismantling activities, various data on project management such as staff expenditure, workers' exposure to radiation and waste arisings were collected continually and stored in the decommissioning database. The database and the lessons learnt will contribute to planning future decommissioning of commercial nuclear power plants.

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Annex A–9

NETHERLANDS (DODEWAARD NPP)

1. INTRODUCTION

The Dodewaard nuclear power plant is a 59 MW(e) boiling water reactor of the pre-Mark 1 GE design. It was the first nuclear power station in the Netherlands, built for the purpose of acquiring knowledge of, and experience in, the design, construction and operation of a nuclear power station in the Netherlands. The plant is operated and owned by the Gemeenschappelijke Kernenergiecentrale Nederland (GKN), a subsidiary of the Samenwerkende electriciteits productiebedrijven (Sep). The Dodewaard NPP is the only power plant owned by GKN. Sep is owned by the four Dutch electricity generating companies. The operation of the Dodewaard plant was characterized by high availability levels, short shutdown periods (four to five weeks), decreasing releases to the environment over the years, and corresponding decreases in the individual and collective radiation doses for personnel and third parties. At the time of the unplanned announcement of the permanent shutdown of the plant by Sep and GKN, the plant was in the middle of a major safety upgrade project.

2. PREPARATION FOR DECOMMISSIONING DURING NORMAL OPERATION

In 1995 a study was performed by Sep, GKN and EPZ (the owner and operator of the Borssele NPP) in order to identify the best decommissioning strategy for the Dutch NPPs. The results of this study showed that, from a technical point of view, more than one dismantling strategy could be envisaged: direct dismantling, in situ entombment and safe enclosure. From the technical, safety and environmental points of view, these three strategies were equally acceptable. However, other arguments, mainly of a financial nature, favoured a strategy under which the Dodewaard NPP would be dismantled after a period of about 40 years. Thus, given that none of the strategies were preferable from a safety or environmental point of view, it was decided that the Dodewaard NPP should be converted into a safe enclosure and dismantled after a period of 40 years.

3. DECISION TO SHUT DOWN THE DODEWAARD NPP (3 October, 1996)

Two major factors contributed to the final shutdown of the Dodewaard NPP.

First, there was a further postponement of a Government decision regarding the construction of new nuclear power stations. Dodewaard was supposed to have been a vehicle for the acquisition of the know-how required for the construction and operation of future nuclear power stations. It became clear that, even allowing for the planned extension to the service life of the plant, the time gap before the construction of any future stations could not be bridged by Dodewaard.

The second argument in favour of closing down the plant was that the operating costs could not be borne in a free electricity market. A small plant such as Dodewaard was never intended to be a competitive electricity generator. The new policy of the Dutch Government is to promote the development of a free European electricity market. Under this policy, there is no place for activities that are only likely to be profitable in the very long term. This is the background to the decision announced on 3 October 1996. The Dodewaard NPP stopped generating electricity on 26 March 1997.

4. GKN 1997–2003 PROJECT (November 1996 – December 1997)

Shortly after the decision to close the plant down was announced, a company-wide planning project called GKN 1997–2003 was started. The date of (end of) 2003 indicates the target date for completion of the plant's conversion into a safe enclosure. The project was intended as a means of co-ordinating the planning of all activities related to the decommissioning of the plant. In essence, the project was to involve the four IAEA decommissioning phases: post-operational phase, preparation for safe enclosure, waiting period and final dismantling. All future activities up to the start of the safe enclosure operation were identified. The preparation activities were included within three projects:

- 'Post-operational activities' project (October 1996 – March 1997)

All remaining activities that could be performed under the existing licence after the termination of electricity production were identified. These included:

- Operation of the plant after 26 March 1997;
- Identification of all process systems that would be superfluous in due course and could then be taken out of service. Within the 'post-operational phase', three subphases were defined in which groups of process systems could be taken out of service, while the (modified) nuclear operation licence was still in force:

- subphase 1: spent fuel in the reactor vessel (until September 1997)
- subphase 2: spent fuel in the spent fuel pool and ready for shipment (planned until mid-2000)
- subphase 3: spent fuel shipped to the reprocessing plant (planned only in the event that licence procedures should be delayed beyond mid-2000)

- Identification of the modifications required to the nuclear licence, resulting in an application for modification of the present operating licence in line with the present situation.

- ‘Preparation for safe enclosure’ project (November 1996 – December 1997)

On the basis of the results of the strategic study previously carried out by Sep/GKN/EPZ, a conceptual design for the safe enclosure has been developed by a GKN project team as a basis for further engineering work. A renewed cost evaluation has been made, and a project plan for further engineering work has been proposed to the GKN management. The four decommissioning phases have been planned in some more detail. Figure 1 shows the various phases as foreseen at present.

- ‘Organizational aspects’ Project (March 1997 – December 1997)

  - Reorganization phases are basically coupled to the various decommissioning phases as defined by the IAEA: post-operation, preparation for safe enclosure, waiting period and final dismantling,

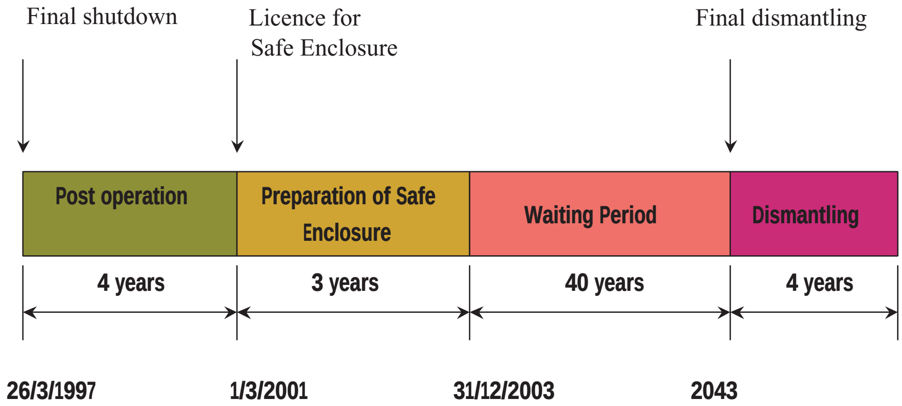

FIG. 1. Decommissioning phases at Dodewaard.

- The organization of the first three phases of decommissioning requires fewer people and (to some extent) people with different skills, so members of the present workforce are gradually becoming redundant and (in the case of GKN) many of them have had to seek employment outside GKN. Accordingly, a social plan was developed and negotiated with the labour organizations. This plan contains a number of essential components:

- There are to be no compulsory redundancies.
- People under the age of 45 are encouraged to leave the organization and are assisted by GKN (outplacement and financial support);
- People over the age of 55, not needed in the new organization, are offered a financially attractive ‘zero-hours contract’ and have to retire at the age of 60;
- People older than 45 will be involved in the activities of the new organization and have the guarantee that they can remain in GKN’s service until retirement at the age of 60;
- The social plan contains the selection rules for future reorganizations.

The ‘GKN 1997–2003’ Project was completed in December 1997, and the first reorganization came into effect on 1 January 1998.

5. REORGANIZATIONS AT GKN (1 January 1998 and subsequent dates)

Figure 2 shows the basic form of the operating organization as per 31 December 1998. The number of employees on 3 October 1996 was 153. In addition, about 50 people employed by third parties worked on the site.

The characteristics of the post-operational phase are:

- the spent fuel is still on the site;
- the (modified) operating licence is still in force;
- irreversible decommissioning activities (for example, dismantling of systems) are not possible.

On 1 January 1998 GKN reorganized itself into three basic sections:

- Operation and maintenance
- Decommissioning activities
- Personnel and support.

At the start of this phase, GKN had a staff of 96 persons; this will gradually decrease to about 50 people by the end of the post-operational phase.

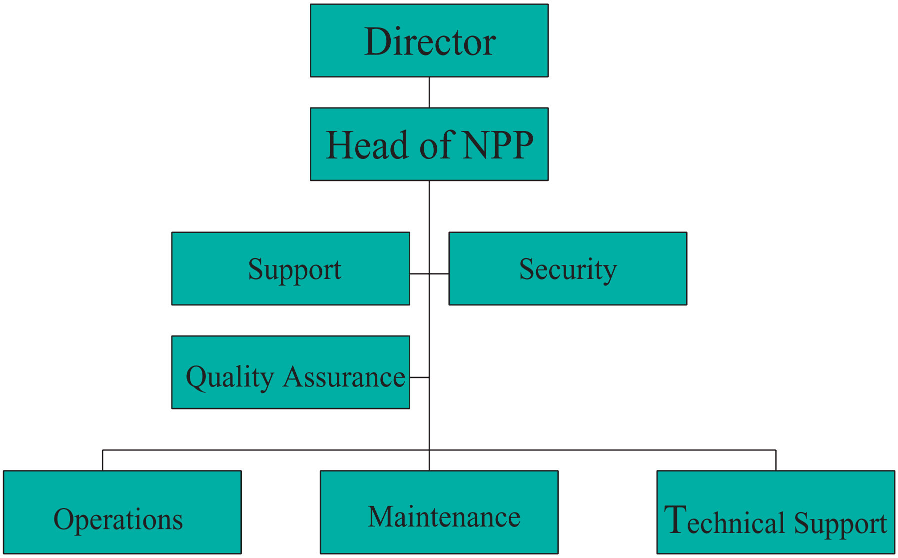

FIG. 2. Basic form of operating organization on 31 December 1998.

Figure 3 shows the organization diagram for this phase.

The characteristics of the safe enclosure preparation phase are:

- all fuel has been shipped from the plant;
- a new licence for the preparation of the safe enclosure and waiting period is in force;
- irreversible decommissioning activities (component dismantling, construction of new structures and systems for operation during safe enclosure) are possible.

Only two sections will remain: the personnel and support section and the decommissioning section. About 30 GKN personnel will remain. The organization of GKN as currently foreseen for this phase will be as shown in Fig. 4.

Details of the organization for the waiting period will have to be developed as part of the safe enclosure design process in phase 2.

6. DECOMMISSIONING ACTIVITIES DURING THE POST-OPERATIONAL PHASE (1 January 1998 to mid-2001)

Following the reorganization of GKN on 1 January 1998, everything was in place for the implementation of the decommissioning project. Previously defined

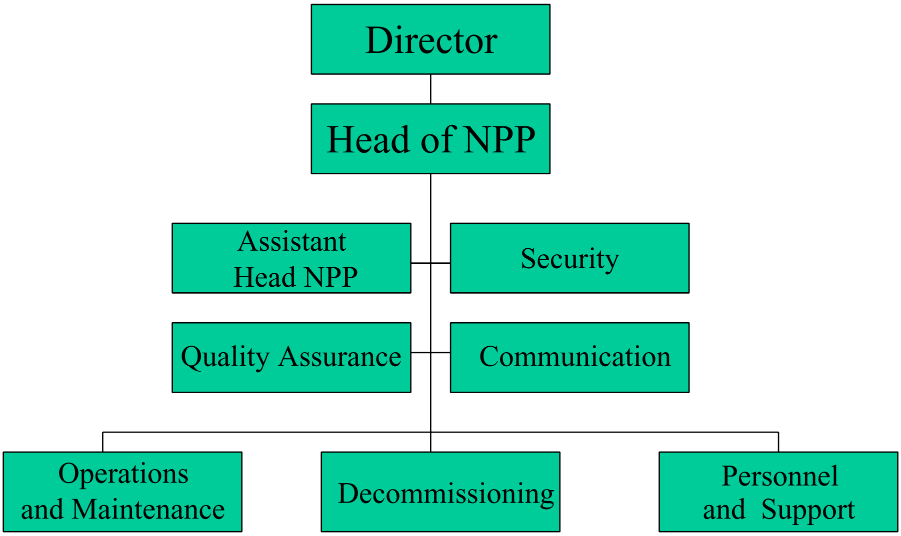

FIG. 3. Organization of phase of 1 January 1998.

strategic goals were converted into project objectives. The project plans were basically ready by the start of the post-operational phase.

The following subprojects were defined and started.

6.1. System decommissioning

The ‘post-operational activities’ project had already planned a logical sequence for the system decommissioning. Combinations of four to five process systems had been grouped into clusters; the actual decommissioning had been planned and is being executed cluster by cluster. No components will be dismantled, but systems are de-oiled, dried and cleaned, electric power is switched off, and the systems are mechanically isolated from other systems and finally sealed. As long as there is spent fuel on the site, only 40 (out of about 100) systems can be taken out of service. This part of the project will be completed by early 2000. Continuation of system decommissioning is only feasible after fuel has been shipped (‘preparation of safe enclosure’ phase).

6.2. Engineering safe enclosure

The ‘preparation for safe enclosure’ project has already defined the conceptual design. The next steps are:

Step 1: January 1998 – June 1999

- Engineering of the basic design of safe enclosure,
- Drafting of the safety report and the environmental impact report,
- Application for the licence for preparation of safe enclosure, and waiting period.

Step 2: June 1999 – mid-2000

- Completion of the detail engineering of the safe enclosure,
- Negotiations with the authorities regarding the licence.

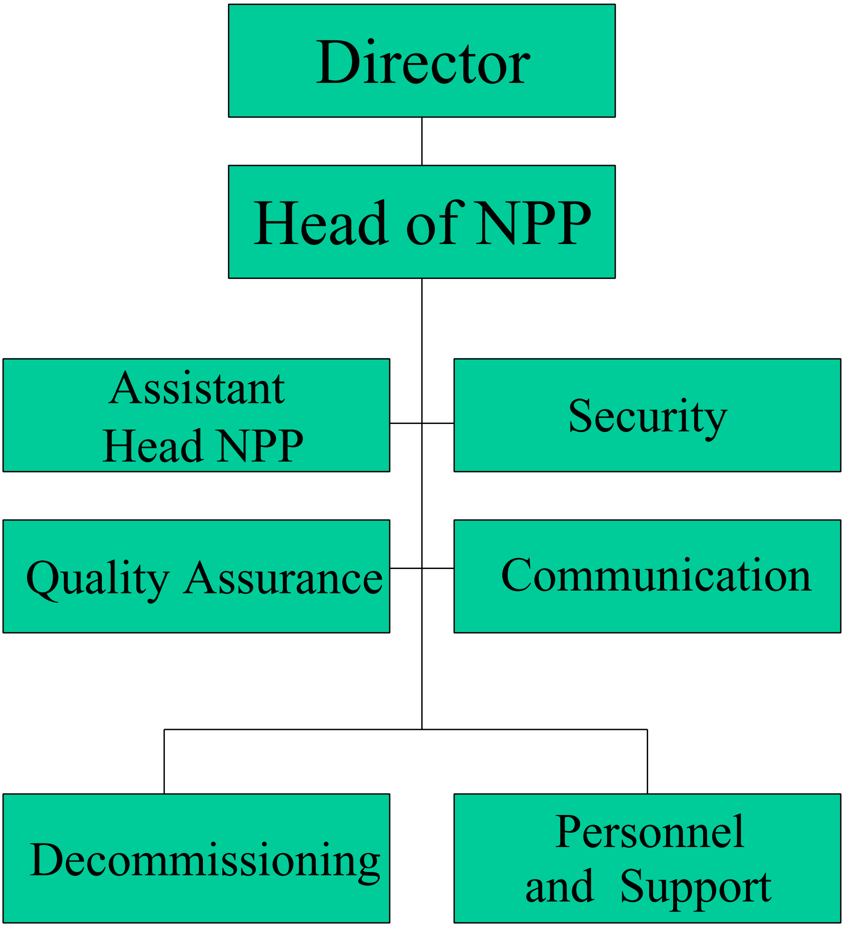

FIG. 4. Organization of GKN as currently foreseen.

The objective is that the detail engineering should be completed and the new licence should be in force by the middle of the year 2000. This is, however, dependent on the spent fuel having been shipped.

6.3. Dodewaard inventory system project

The Dodewaard Inventory System (DIS) is a database containing all relevant data related to radioactive materials and masses, specified per building, room, floor, material type, etc. Its purpose is to deliver all input data from the plant required for waste management, engineering, and safety analysis. The report software has a modular structure so that at a later stage more report modules can easily be added. The database itself can be more detailed, depending on the requirements during the various stages of the project.

At the start of the project, the specific requirements of the DIS were defined by the engineers who designed the safe enclosure. In a later phase, the system decommissioning group took the leading role in defining the requirements relating to health physics and decontamination questions.

This project is subdivided into several project steps:

1. Stage 1: Database definition phase (September 1997 – December 1997)

2. Stage 2: January 1998 – December 1998
   - 2.1. Software development
   - 2.2. Collection of data (measurements) on dose rates and contamination levels in the plant
   - 2.3. Implementation of the database
   - 2.4. Definition of shortcomings;

3. Stage 3: January 1999–2000
   - 3.1. Completion of the software
   - 3.2. Collection (measurement and calculation) of activity data
   - 3.3. Collection (measurement) of more detailed data as defined by system decommissioning.

6.4. Pre-engineering project on decontamination

Chemical decontamination is offered by a number of suppliers. A study has been performed by GKN to evaluate the various processes and suppliers. On the basis of this work, two suppliers were asked to tender for an engineering prestudy. One supplier has been selected, and the conclusions were reported to GKN in December 1998.

6.5. Pre-engineering project on the removal of control rod blades

An external engineering firm was invited to advise on the technical and financial issues associated with the removal of the control rod blades. The conclusions were reported to GKN in December 1998.

6.6. Historical and operational records

The Dodewaard nuclear power plant has had a significant impact on Dutch society in recent years, and its history is considered to be of historical relevance. The Dutch State Archives of the Gelderland province showed an interest in taking over and storing historically relevant documents from the Dodewaard NPP. A joint project was started in 1998 and will be completed by the end of the year 2000. Another project involving the filing of operational and management records has been started. The intention is that, by the beginning of organizational phase 3 (preparation of safe enclosure), a centralized record filing system should be in place which also fulfils future operational needs and final dismantling.

7. OPERATIONAL ACTIVITIES DURING THE POST-OPERATIONAL PHASE

The operational activities relate mainly to the presence of spent fuel on the site. However, reactivity and loss-of-coolant accidents are not possible anymore and, soon after final shutdown, the residual heat from the fuel has been reduced to a very low level. The emergency preparedness programme can therefore be reduced substantially, but not abolished.

A number of systems have become redundant and can be handed over to the decommissioning section for subsequent decommissioning.

Systems that are not (yet) redundant have to be maintained in the usual way. Systems that have been taken out of service have to be maintained as well, but the effort will be reduced considerably; in most cases visual inspection of corrosion phenomena and mechanical integrity will be sufficient.

Surveillance is based on the continuation of the existing programme (as far as applicable), but the ageing programme has been stopped.

Other operational activities that will be continued are:

- monitoring of radioactive releases to the environment
- monitoring of water and air conditions in the plant
- health physics

- radioactive liquid waste treatment
- transport of spent and remaining fresh fuel
- removal of solid radioactive materials from the fuel pool and other locations
- maintaining operational records
- training of employees
- security.

8. UNCERTAINTIES

There are some uncertainties which may jeopardize the decommissioning project for the Dodewaard NPP. The main uncertainties which pose a threat are as follows:

Inability to transport spent fuel

Discussions in Belgium and in the Netherlands on the safety of the spent fuel transport routes have temporarily halted the shipments from the plant to the fuel reprocessor. The result of this delay is that GKN will not be able to remove all fuel from the site before the end of the year 2000. As long as spent fuel is on the site, it is not possible to complete the decommissioning of a large number of process systems and the activities with respect to the preparation for safe enclosure.

Government policy with regard to decommissioning of NPPs

Even though the Dutch electricity sector notified the Dutch Government in 1995 that the strategy for NPPs was to be dismantling after a safe enclosure period of 40 years, the Dutch Government has not yet developed its own policy of decommissioning. Early in 1996, the regulatory authorities in the Netherlands declared that they deemed the electricity industry's strategic decision to be fair. However, since the premature shutdown of Dodewaard was announced, no indication has been received that the strategy of dismantling the plant after a waiting period of 40 years is acceptable. Nevertheless, GKN intends to submit the application for a licence for 'preparation for safe enclosure and waiting period' in May 1999. It remains to be seen whether or not the licence for preparation of the safe enclosure will be granted. The issue is likely to be debated in the Dutch Parliament before a licence is granted. It is not clear whether the Dutch Parliament will approve the electricity industry's strategy.

Dissolution of the Dutch Electricity Generating Board (Sep)

Liberalization of the European and Dutch electricity markets has set in motion a process which will eventually lead to the disappearance of Sep, GKN's parent company. Already, Sep has been transformed into a relatively small organization. Sep and GKN are looking to hand over the ownership of GKN to another company. One possibility for GKN is to be handed over to the Dutch Central Organization for Radioactive Waste (COVRA). COVRA is considered to be the best organization to perform the functions necessary during the waiting period. Moreover, the expected lifetime of COVRA is such that this organization should be able to take care of the dismantling of the Dodewaard NPP after the waiting period of 40 years.

The above mentioned uncertainties, especially the first two, could cause significant delays to the activities to be carried out by GKN. In the meantime, the process of reducing the size of the GKN organization continues: younger people are finding other jobs and older people are retiring. Up to now, GKN has been able to manage the reduction of its workforce by giving people dual functions and making use of the (limited) redundancy provisions already made. In the future, GKN will have to rely to a greater extent on temporary personnel hired from other companies.

Annex A–10

SLOVAKIA (DECOMMISSIONING OF SLOVAKIA'S NPPS)

1. Introduction

This annex provides an example of organizational and management aspects of NPP decommissioning in Slovakia.

1.1. Background to decommissioning in Slovakia

Nuclear power generation in Slovakia is based on NPPs with pressurized water reactors of the WWER-440 type.

There are two nuclear sites in Slovakia. Two nuclear power plants with two WWER-440 reactors each are currently operating in Jaslovské Bohunice, and one NPP with a heavy water moderated, CO_2 cooled reactor (HWGCR) is under decommissioning at the same site. The second nuclear site is Mochovce, where two nuclear power plants with two WWER-440 reactors each are under construction; the first unit was commissioned in 1998. All nuclear power plants are owned and managed by Slovenské elektrárne a.s. (Slovak Electric plc).

The first two units in Jaslovské Bohunice with V-230 reactors (older Soviet design) were commissioned in 1978 and 1980, and the next two units with V-213 reactors (advanced type 230) in 1984 and 1985.

The first two units (V-230) have to be refurbished to assure the safety standard of western PWRs. Partial refurbishment was already realized from 1991 to 1993; stepwise refurbishment of all safety related equipment planned for the period of 1995 to 1999 is in progress. The design basis lifetime of these units is 25 years, that of the upgraded WWER-440 (V-213 units) is 30 years.

The pilot nuclear power plant A-1 was a HWGCR channel type reactor KS 150 (refuelling during operation) with a power output of 143 MW(e). The main production building in the NPP comprises the reactor hall building with reactor vessel, heavy water moderator system and equipment for refuelling and spent fuel handling, coolant system (six turbocompressors, six steam generators and piping), and the turbine hall equipped with three turbines. The NPP was in operation from 1972 and finally shut down in 1977, after a primary coolant system integrity accident. In 1979, on the basis of the results of technical, economic and safety analyses, it was decided to decommission this plant.

A list of large nuclear facilities in Slovakia is introduced in Table 1.

TABLE I. NUCLEAR FACILITIES IN SLOVAKIA

Nuclear facility	Net power MW(e)	Type	Startup	Final shutdown
NPP A-1	110	HWGCR	1972	1977
NPP Bohunice 1, 2	2 × 408	WWER440/230	1978, 1980	2003–2005
NPP Bohunice 3, 4	2 × 408	WWER440/213	1984, 1985	2014–2015
NPP Mochovce 1–4	4 × 408	WWER440/213	1998, constr.	2028
Interim Spent Fuel Storage		wet, pool	1987	2037
Conditioning Centre		Cementation, incineration, bituminization, compaction	1998	2038
Bituminization-VÚJE		Experimental facility	1984	2007
Incinerator-VÚJE		Experimental facility	1986	2007

1.2. Decommissioning policy and legislation

The policy of nuclear facility decommissioning and the role of the Nuclear Regulatory Authority of the Slovak Republic (NRA SR) in this process are codified in the Act on Peaceful Uses of Nuclear Energy (Atomic Energy Act). In the relevant part of this act, decommissioning is defined.

In accordance with SR legislation, the primary responsibility, technically as well as financially, for all measures necessary for the safe handling and disposal of radioactive waste and for the decommissioning of nuclear facilities is on the licensee, under supervision of the national regulatory authorities. Currently, feasibility studies and decommissioning plans are required by law for all nuclear facilities.

The Ministry of Health is the authority that establishes generally applicable standards for residual radioactivity of released property (Act No. 272/1994 Coll. on Protection of Population Health, amendments No. 222/1996 Coll. and No. 290/1996 Coll.).

The Government Decision No. 190/1994 has determined the basic strategy for radioactive waste management in Slovakia. The organization SE-VYZ was set up within Slovak Electric plc on 1 January 1996, to take responsibility for radioactive waste conditioning (predisposal and disposal phases) and nuclear facility decommissioning.

Since 1995, the State fund for NPP decommissioning including spent fuel and radioactive waste handling and disposal has been established by Act No. 294/1994 Coll. The NPP owners must contribute to this fund 10% of the market price of energy sold to the grid. A State grant is the other source of income to the fund. The existence of this fund has enabled many activities connected with decommissioning of HWGCR A-1 and the preparation of a documentation for WWER reactor decommissioning in Slovakia to commence.

The Act of the National Council of SR No. 127/1994 concerning environmental impact assessment establishes the responsibility of the Ministry of Environment to accommodate proposals for decommissioning alternatives before the start of decommissioning. The requirements of the Nuclear Regulatory Authority, the Ministry of Health and other competent authorities are obligatory.

The relationships between the organizations and authorities concerned with decommissioning, particularly with safety, radiation protection, waste management and financing, are shown in Fig. 1.

2. ORGANIZATION AND MANAGEMENT OF DECOMMISSIONING

Following the Government Decision No. 190/1994, a new subsidiary of Slovak Electric plc (SE-VYZ) was established on 1 January 1996 and has assumed the responsibilities related to NPPs, decommissioning installations, radioactive waste (from NPP operations and decommissioning, and institutional waste) conditioning and disposal, and spent fuel management. The principal duties and responsibilities of this subsidiary are shown in Fig. 2.

2.1. Planning for NPP decommissioning

Two types of decommissioning plan have been developed for the NPPs:

- feasibility studies for the NPPs with WWERs and A-1;
- the final decommissioning plan of the NPP A-1 — first phase.

2.1.1. Feasibility studies

On the basis of lessons learnt during NPP A-1 decommissioning, a thorough and timely approach had been selected for the preparation of WWER NPP decommissioning. Feasibility studies resulted in the selection of a preferred decommissioning option.

The documents for the final period of operation with a view to a selected option were prepared for one of the WWER NPPs (V-1).

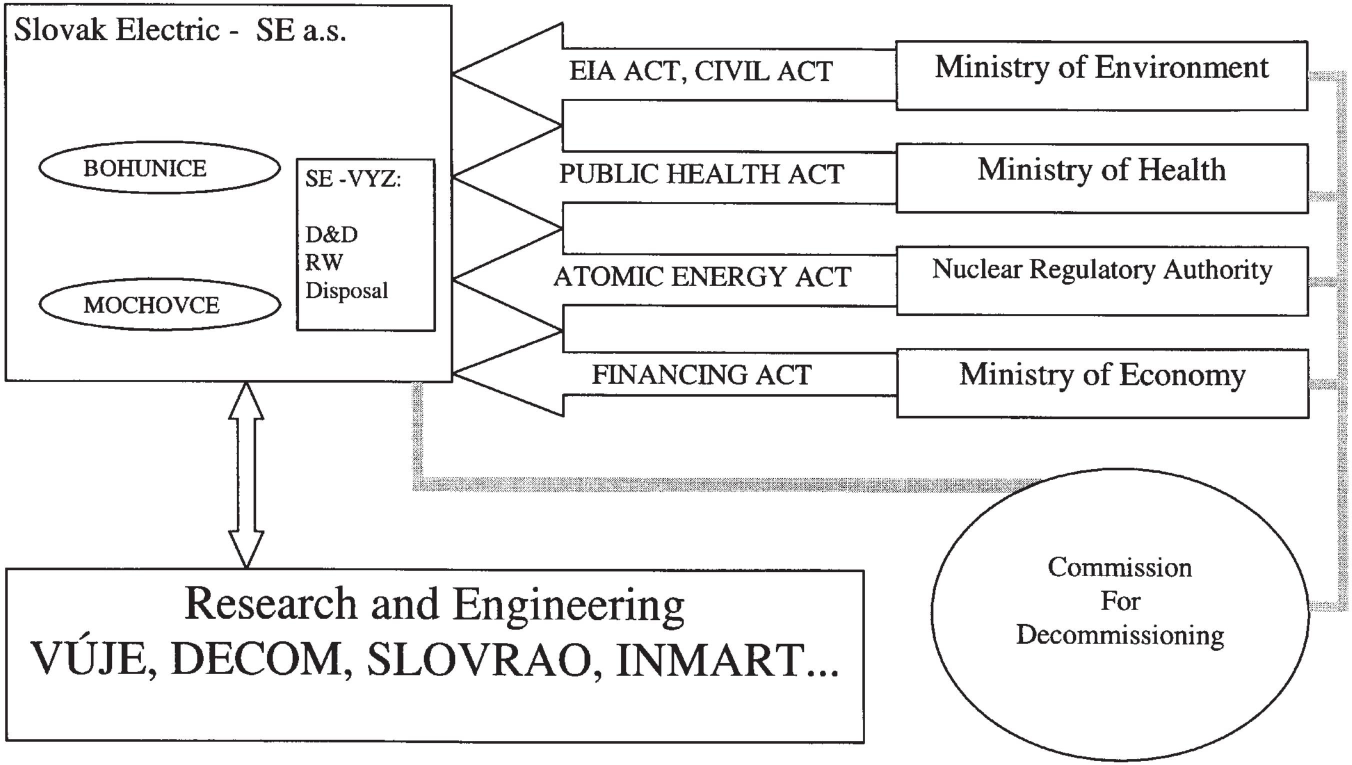

FIG. 1. Nuclear facilities in Slovakia.

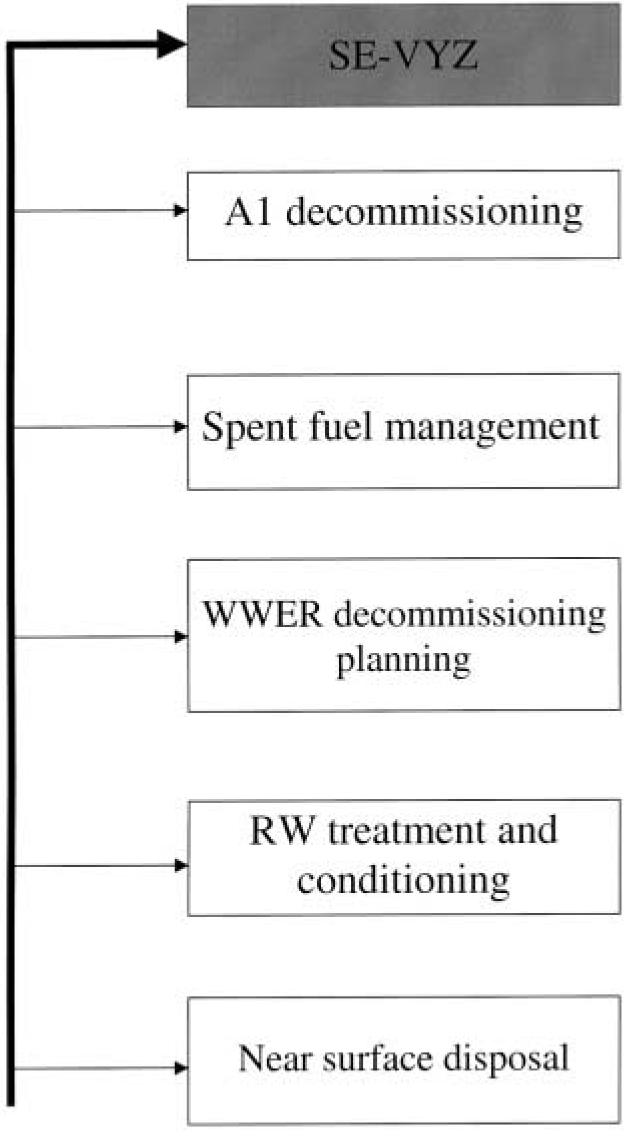

FIG. 2. Responsibilities of SE-VYZ.

The following five decommissioning options were analysed in detail:

(1) Immediate dismantling of the NPP after final shutdown,
(2) Safe enclosure of parts of the reactor building, ‘hermetic area’ for each unit separately;

(3) Safe enclosure of the reactor cavity with each reactor separately;
(4) Safe enclosure of the whole reactor building;
(5) NPP closing under surveillance (stage 1, according to IAEA classification).

It should be emphasized that the final goal for options (2 to 5) was deferred dismantling to a 'green field' after a period of 70 years. The results of these technical, economic and safety analyses of the various decommissioning options for V-1 served as one of the basic documents for the decision making process.

Multiattribute analysis was used for complex assessment of the results and the selection of the preferred option. Options including a safe enclosure period were generally selected for WWERs, but a final decision will only be taken at the time of permanent shutdown.

2.1.2. Decommissioning of NPP A-1

Although the decision to decommission NPP A-1 was taken as early as 1979, work progressed only slowly, owing to technical, legislative and financial constraints. These included unavailability of conceptual plans and legislation for decommissioning, inadequacy of radioactive waste treatment technologies, lack of disposal facilities, difficulties in shipping the spent fuel off-site and lack of funds for decommissioning. Therefore, work was carried out in two areas in parallel:

- R&D on decommissioning and radioactive waste management;
- actual works on NPP A-1 decommissioning.

As a result of technical, economic and safety analyses, the following four phases were selected for the NPP A-1 decommissioning strategy:

(1) Bringing NPP A-1 into a so-called radiologically safe status;
(2) Preparation of the safe enclosure;
(3) Safe enclosure;
(4) Deferred dismantling.

A final decommissioning plan for the first phase has been developed and approved in 1995, and a feasibility study for activities following the first phase has been elaborated.

The status at the end of the first phase is characterized by:

- transport of the entire spent fuel inventory off-site, or its temporary storage on-site in an appropriate storage facility;
- treatment and conditioning of all waste for disposal or storage;

- decontamination of equipment and structures;
- construction of required stores and necessary containment barriers.

As the decommissioning plan for the first phase includes alternative solutions for some tasks, details of the specific solution to be selected are being elaborated and will be approved separately. The tasks with highest priority (safety related) are currently being realized and, in line with the project, annual implementation schedules are produced.

The project organization is structured as shown in Fig. 3.

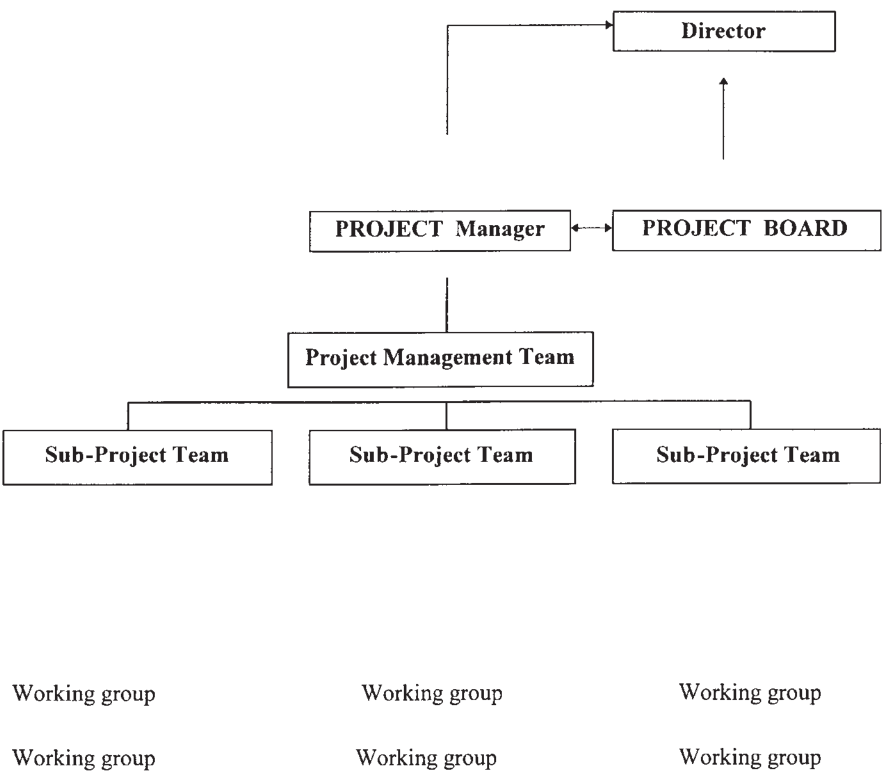

FIG. 3. Structure of project organization.

Annex A–11

SPAIN (VANDELLÓS 1 NPP)

1. INTRODUCTION

This document describes the decommissioning policy of large nuclear installations in Spain, the organization and management aspects, and the responsibilities of the institutions involved in the dismantling projects. Particular attention is paid to the Vandellós 1 NPP decommissioning project that is currently under way.

2. RESPONSIBILITIES IN THE DECOMMISSIONING PROCESSES OF NUCLEAR INSTALLATIONS

ENRESA (National Radioactive Waste Company) has, by law, the responsibility for the management (final steps) of radioactive waste, including the management of decommissioning activities.

The Ministry of Industry and Energy (MINER) authorizes and applies conditions and options for the decommissioning project on a case by case basis. ENRESA is expected to conduct the necessary studies and propose the best decommissioning alternative, taking account of the ‘radioactive waste general plan’ and the national policy and strategy.

Once the option proposed by ENRESA is accepted by MINER, following Nuclear Safety Council (CSN) approval, ENRESA must submit for approval, within a fixed time, the decommissioning plan (DP), which in detail describes the contents of the accepted alternative (see Section 5 of this Annex). The DP should be approved by the CSN, which may impose additional limits and conditions.

In addition, ENRESA must prepare the environmental impact study which is submitted to competent authorities as required. Eventually, an environmental impact declaration is promulgated by the Environmental Ministry, jointly with the CSN.

Finally, following these assessments, the MINER authorizes transfer of the operating licence from the previous owner to ENRESA, which allows it to undertake decommissioning activities, within the conditions stipulated by CSN and the Environmental Ministry.

Through this licence transfer, ENRESA acquires the conditions of a responsible licensee, while the site property is retained by the previous owner. Once the decommissioning activities have been completed, the site property is returned to its previous owner.

Two organization structures can exist during the process:

ENRESA

- Propose options and alternatives for decommissioning;
- Prepare the DP;
- Seek approval of the DP;
- Plan and engineer the dismantling activities;
- Specify the work packages;
- Subcontract services for execution of the work;
- Prepare work procedures;
- Prepare cost estimates.

Utility owner

- Defuel the reactor;
- System deactivation;
- Operational waste conditioning;
- Plant operation and maintenance.

3. STRATEGIES AND DECOMMISSIONING POLICIES

General guidelines for radioactive waste management are also taken into account:

- The selected disposal option for the low and intermediate radioactive waste is a near surface engineered storage facility, operated by ENRESA (El Cabril).
- Spent fuel is high level waste and will be not reprocessed (except for Vandellós 1 fuel in France). Spent fuel is stored in the pools (fuel building) of the plants for which their capacity has been increased.

It is assumed that a decision to dispose of the high level waste in a deep geological repository will be taken in the future. The Spanish national policy for decommissioning of nuclear facilities, the general radioactive waste plan, endorses the option of total dismantling (IAEA Stage 3), to be initiated four to eight years after permanent shutdown.

For Vandellós 1, because of the reactor type (natural uranium, gas cooled and graphite moderated), IAEA Stage 2 was selected, deferring the final dismantling by about 30 years. This option was selected in the light of economic, radiological, regulatory and waste management aspects and in accordance with the policy adopted in France for similar plants.

4. LEGAL AND REGULATORY FRAMEWORK

In Spain there are no specific rules for decommissioning. Decommissioning projects are regulated by general law only. CSN (the Spanish regulatory body) is responsible for regulating nuclear safety and radiological protection and applying appropriate limits and conditions as necessary.

For environmental protection, the corresponding ministry is responsible for the 'environmental impact declaration', which is assessed jointly with CSN (see Section 1).

Clearance criteria for radioactive materials are promulgated by CSN, on a case by case basis.

5. THE DECOMMISSIONING PLAN

The decommissioning plan based on Vandellós 1 provides for the following:

(1) Safety Report
- (a) facility operating history
- (b) facility radiological status
- (c) decommissioning alternative and project description
- (d) final state description
- (e) safety analysis

(2) radiological impact assessment
(3) environmental radiation monitoring plan
(4) technical specifications
(5) dose assessment
(6) organization and responsibilities
(7) project schedule
(8) quality assurance programme
(9) radioactive waste management
(10) radiation protection programme
(11) emergency plan
(12) physical security plan
(13) health physics plan
(14) environmental impact assessment.

6. FINANCE SYSTEM

A fund has been established to finance the decommissioning. The approach adopted for funding radioactive waste management activities and decommissioning is to levy a certain percentage (‘quota’) on electricity sales. The income resulting from this quota, including the accumulated interest, will meet the projected future expenditure for complete nuclear waste management (including decommissioning). This fund is managed by ENRESA.

The Government establishes the value of the quota, according to the estimates made in the general radioactive waste plan. The methodology used to calculate the quota is based on the principle that the income of one year is proportional to the electricity generated by the NPPs during the same year.

7. VANDELLÓS 1 NPP APPROACH

7.1. Project history

The Vandellós 1 Nuclear Power Plant (CNV1) is located on the Mediterranean coast in the province of Tarragona (Spain).

The plant is of the natural uranium graphite–gas type, and its design is based on a project developed jointly by Electricité de France (EDF) and the Commissariat à l’énergie atomique (CEA). This led to the construction of this type of reactor at the French Saint Laurent des Eaux plant (SLA 1 and SLA 2) and at Vandellós. The thermal power of the plant is 1670 MW(th); the electrical output is 500 MW(e).

Commercial operation started in May 1972; its final shutdown, following a fire in the turbines, took place in October 1989, after 17 years of operation.

The integrated nuclear steam supply system (reactor core, primary carbon dioxide gas heat transfer circuit and steam generating heat exchangers) is contained inside the prestressed reactor vessel (49 m high, hexagonal section).

7.2. General description of the decommissioning option

The plan submitted by ENRESA, following the assessment of other possible alternatives, consisted of partial dismantling of the plant, in order to reach IAEA Stage 2.

In response to this proposal, the general directorate for energy (MINER) issued a resolution on 27 November 1992, following evaluation, by the Nuclear Safety Council, of the options proposed by ENRESA, in which it accepted the selected alternative.

The option accepted consisted of first removing the spent fuel and conditioning the operating radioactive wastes, followed by dismantling of almost all the structures

TABLE I. PHASES OF THE DISMANTLING AND DECOMMISSIONING PROJECT

Project	Phase	Period	Main activities	Tasks
Vandellós 1 dismantling and decommissioning project	Phase 1: Basic design and licensing	From Feb. 1992 to May 1994	Basic de-commissioning engineering and planning	Engineering and planning
			Drawing up of licensing documentation (dismantling and decommissioning plan).	
	Phase 2: Design	From June 1994 to Dec. 1997	Stage 2 Detailed engineering	
	Phase 3: Execution	From Jan. 1998 to 2001	Site preparation	Works at site
			Implementation of level 2 dismantling	
			Preparation of safe enclosure	
Safe enclosure	30 years			Surveillance, maintenance

and components located outside the reactor vessel, except for those ensuring confinement of the vessel itself. No action will be taken with respect to the vessel until completion of the waiting (safe enclosure) period.

The vessel, with the reactor and the internals, will be properly isolated, the various penetrations to the outside being closed and sealed. The residual activity contained inside the vessel will be confined and isolated and will decay during the safe enclosure period.

The site itself will be kept under surveillance both during the dismantling and the safe enclosure phases, after which the remaining installations will be left within a new site perimeter in a monitored condition.

After the safe enclosure period, which will last some 30 years, total dismantling of the remaining installations will be undertaken, allowing complete clearance of the site.

7.3. Project phases and organization

To develop the accepted dismantling option, ENRESA has structured the 'dismantling and decommissioning project' in different phases, as shown in Table I.

BASIC DESIGN AND LICENSING (PHASE 1)

Basic engineering and planning: This process consisted of studies and activities for the development of criteria leading to basic documents to be used for developing the overall project.

Licensing documentation: The aim was to develop the documentation required for approval of the decommissioning plan.

Organizational structure

The organization structure for ENRESA provides a project manager supported by appropriate specialists (licensing, safety, planning, QA, etc.).

The project team was supplemented by a subcontracted engineering company, which provided engineers and experts for the necessary disciplines (dismantling, radiological protection, waste management, programming, cost control, etc.) (Fig. 1).

This organization continued into Phase 2 until the start of work on-site.

In addition, the utility maintained the operational structure with only minor modifications but with gradual reduction of staff numbers.

The main activities undertaken by the utility comprised:

- deactivation of redundant operating systems;
- operational waste conditioning (liquid wastes, spent resins, etc.);
- preconditioning of fuel element graphite sleeves; this graphite was stored in silos;
- transferring spent fuel from reactor to pools; after a short residence time in the pools, the fuel was transported in batches to France for reprocessing;
- removal and decontamination of spent fuel pool internals;
- pool water treatment and discharge.

Figure 2 shows the utility organization during the predecommissioning period before and after the spent fuel was removed from the site.

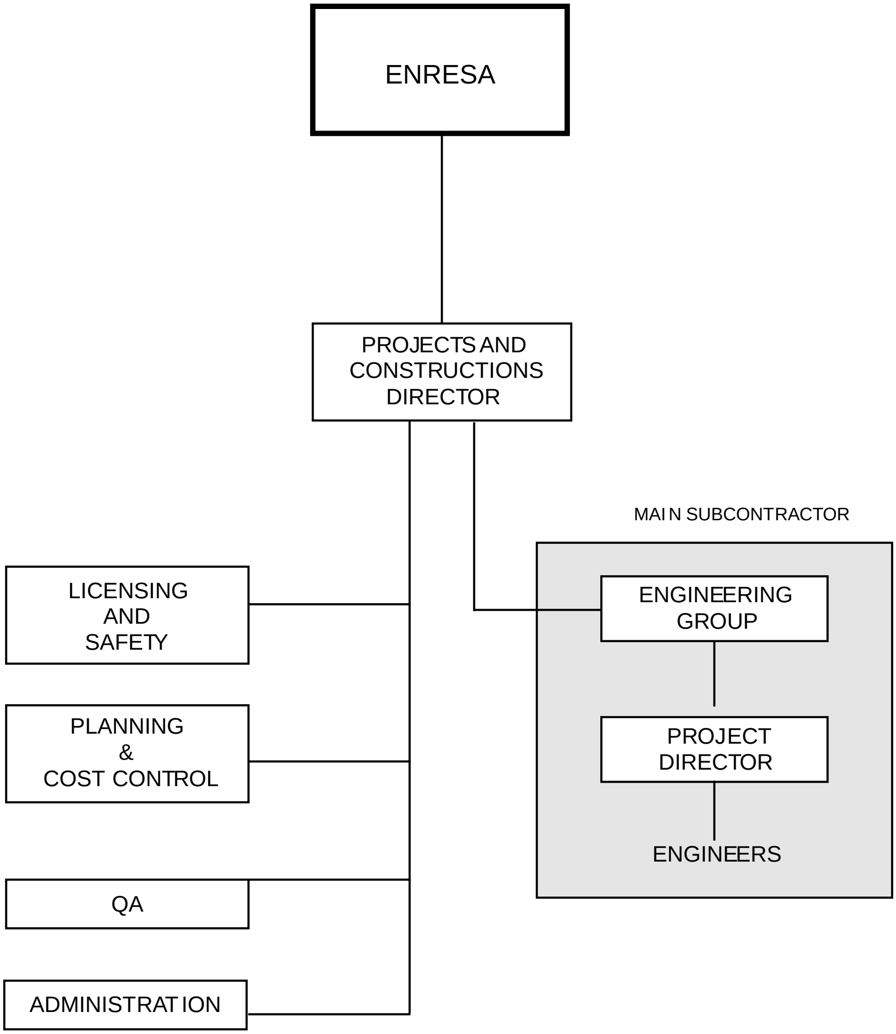

FIG. 1. ENRESA organizational structure.

DESIGN (PHASE 2)

Stage 2 — detailed engineering of decommissioning: This process consisted of undertaking a number of engineering tasks and design activities aimed at preparing and facilitating execution of dismantling, including the design of modifications and new systems and structures as required.

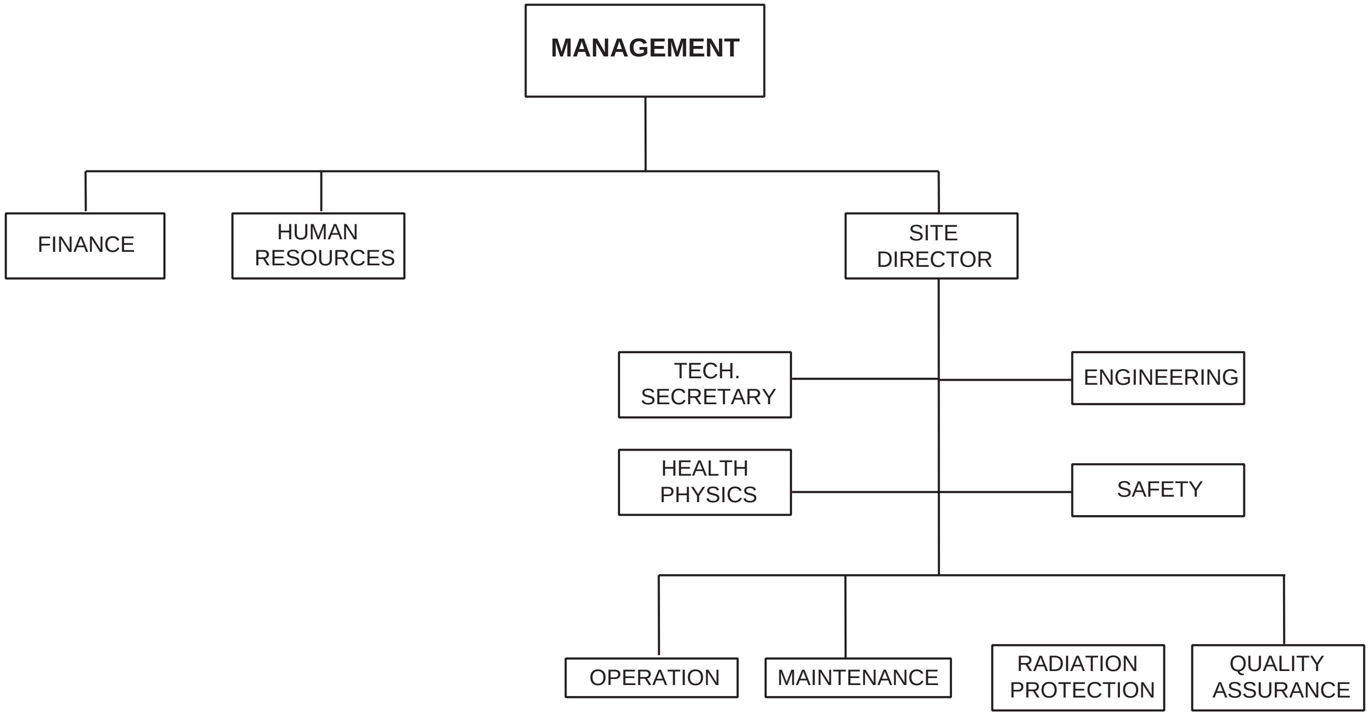

FIG. 2. Utility organization during predecommissioning period.

These activities included preparation of the specifications for contracting services and equipment, as well as drawing up work procedures for various support and decommissioning tasks.

EXECUTION (PHASE 3)

This phase began once approval was obtained from MINER (January 1998) and comprises three periods.

(1) Site preparation period.
- (a) Adapt utility systems and structures for dismantling (electrical, service water, I&C, waste treatment);
- (b) Implement new systems;
- (c) Dismantling conventional (inactive) systems and equipment.

(2) Dismantling period
- (a) Remove all radioactive parts to achieve Stage 2 decommissioning;
- (b) Static confinement of the reactor vessel (safe enclosure);
- (c) Waste management;
- (d) Building decontamination;
- (e) Building demolition.

(3) Final period
- (a) Implementation of systems required for the safe enclosure period; construction of new reactor building;
- (b) Final radiological survey;
- (c) Site restoration;
- (d) Release of parts of the site;
- (e) Restricted site configuration.

Once this last period has been completed, the safe enclosure period will begin for a predicted duration of 30 years.

Organization

During phase 3, the licensee responsible for carrying out the decommissioning activities is ENRESA. The owner will retain property of the site. In this sense, the only organization of interest is ENRESA, as shown in Fig. 3.

In this organization key positions are held by ENRESA staff; the rest are subcontracted. It is interesting to note that the different work packages will be

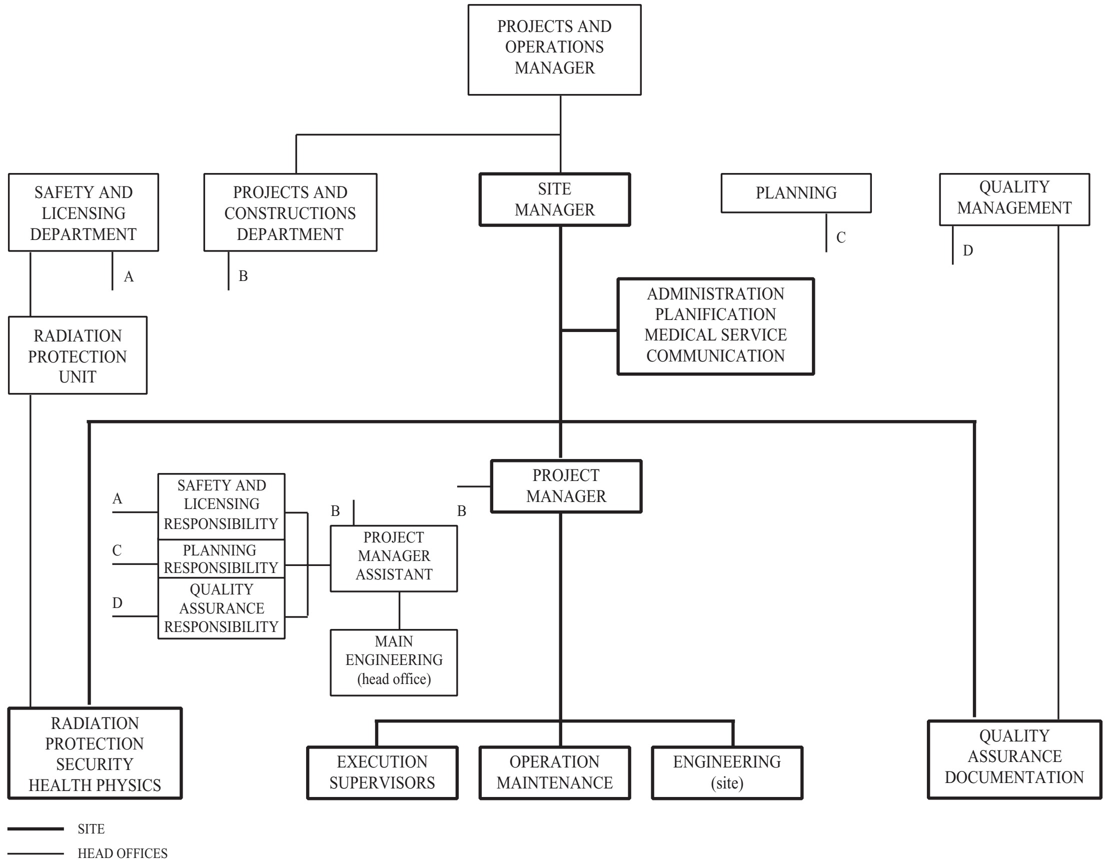

FIG. 3. ENRESA structure.

subcontracted separately. There is no main subcontractor carrying out the whole of the dismantling activity.

Table II shows the different activities/services subcontracted by ENRESA for this project. Figure 4 provides a sketch of the regulatory process for Vandellós 1 decommissioning.

MANAGEMENT OF DECOMMISSIONING PRODUCTS

The waste management plan includes the following:

(1) All materials arising from the decommissioning process and classified as contaminated, including those with very low levels of contamination (eligible for declassification and conventional management), for example:

(a) metallic components, equipment and structures to be dismantled;
(b) concrete and rubble from contaminated areas;
(c) other miscellaneous waste (electrical wiring, plastics, etc.).

TABLE II. LIST OF SUBCONTRACTED WORK PACKAGES

- RADIOLOGICAL CHARACTERIZATION
- SITE PREPARATION
    - ELECTRICAL SYSTEMS
    - FLUID SYSTEMS
    - I&C SYSTEMS
    - CIVIL WORKS
- ACTIVE AND CONVENTIONAL DISMANTLING
- REACTOR VESSEL SEALING
- DECONTAMINATION
- RADIOLOGICAL PROTECTION SERVICE
- MONITORING SERVICES
- DEMOLITION WORKS
- DOSIMETRY
- PLANT OPERATION AND MAINTENANCE (UTILITY)
- ENGINEERING
- WORKS SUPERVISION
- SECURITY

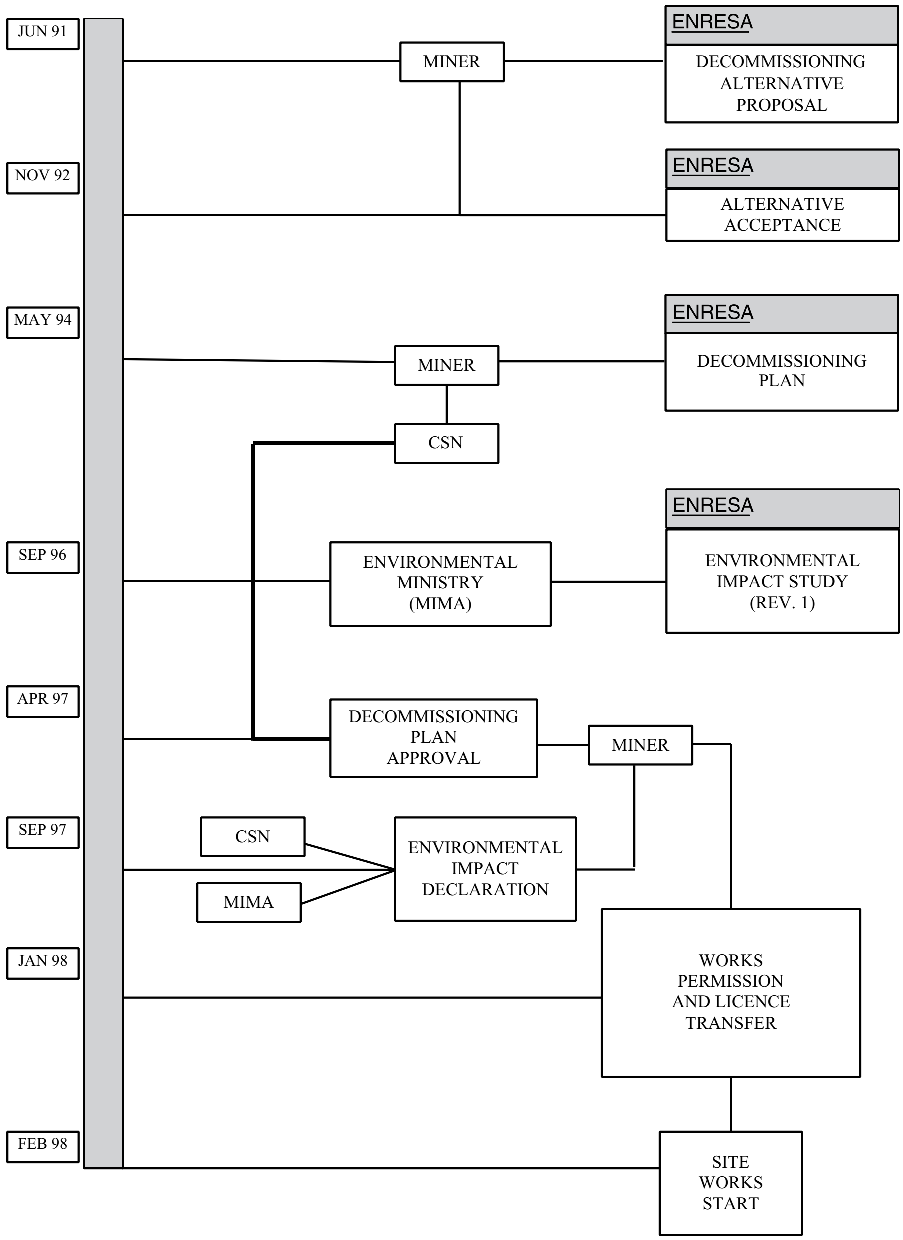

FIG. 4. Regulatory process for Vandellós 1 decommissioning.

(2) Wastes arising from decommissioning work (secondary wastes), such as:

(a) technological wastes produced by the decommissioning work;
(b) solid wastes arising from the treatment of liquid and gaseous effluents produced by the decommissioning operations.

(3) Plant operational wastes stored on-site at the beginning of decommissioning, in particular:

(a) preconditioned graphite wastes;
(b) final operational process wastes.

The waste management plan considers all these operations; this includes handling of this material up to preparation for transport to the final destination.

CSN, after review, has issued the criteria for applying clearance in the decommissioning of Vandellós 1 NPP [1].

Either:

• total β/γ	0.2 Bq/g
• total α	0.1 Bq/g
• surface contamination total β/γ	0.4 Bq/cm^2
• surface contamination total α	0.1 Bq/cm^2
• surface contamination weak β/γ	4 Bq/cm^2

Or:

Radionuclide specific values as per draft document Draft SS-111-G-1.5 of the IAEA (Clearance Levels for Radionuclides in Solid Materials — 1995, eventually published as TECDOC-855 [2]).

- Generic conditional clearance for metallic scraps as defined in the draft document ‘Recommended Radiological Protection Criteria for the Recycling of Metals from the Dismantling of Nuclear Installations (Nov. 1994)’, elaborated by the Article 31 Expert Group of Euratom. This document was eventually published in 1998 [3].
- Generic conditional clearance for demolition debris as defined in SS-111-P-1.1 [4].
- The CSN could consider proposals for other values if the final destination of the residual materials can be conditioned and an ‘ad hoc’ assessment can justify compliance with the following radiological criteria:

• individual dose	≈10 μSv/a
• skin dose	≤50 mSv/a
• collective dose	≤1 man·Sv
• doses due to events of low probability	≤1 mSv/a

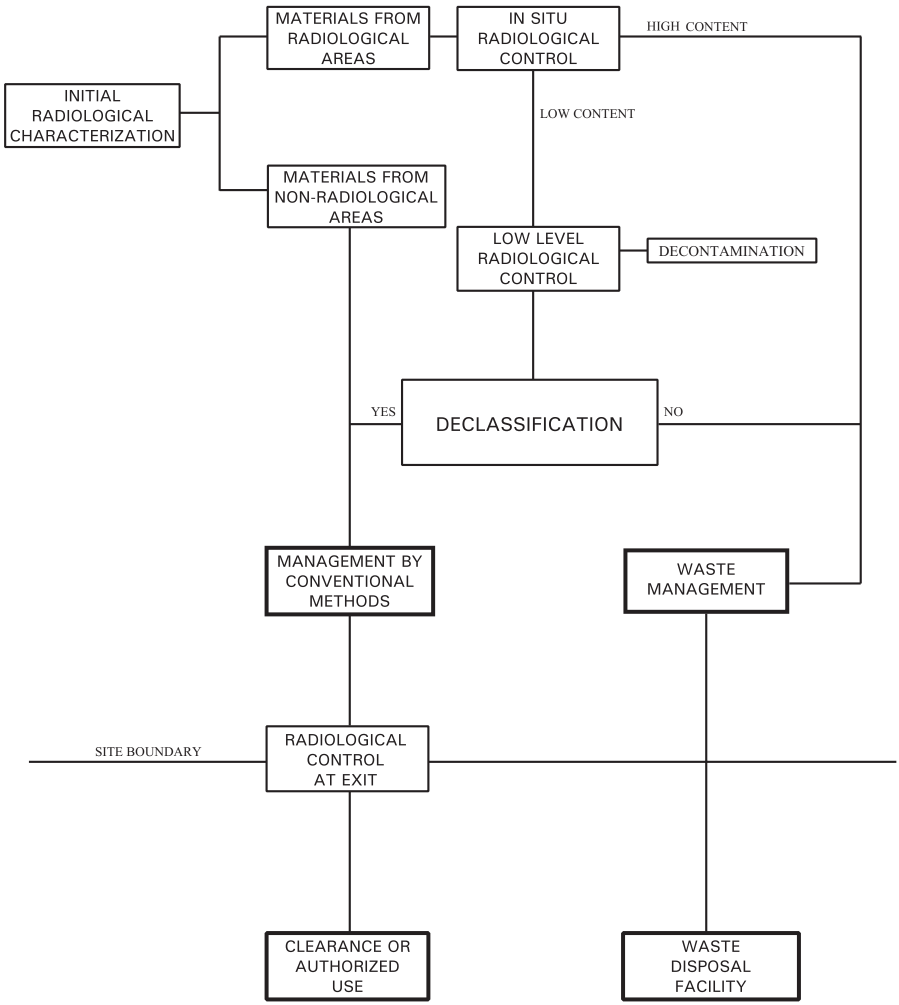

FIG. 5. Material/waste management during Vandellós decommissioning.

A strict control programme is required to support and verify the application of the above criteria before the release of the residual materials. Figure 5 gives an overview of material/waste management during Vandellós 1 decommissioning.

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Annex A–12

UNITED KINGDOM (THE REGULATION OF DECOMMISSIONING IN THE UNITED KINGDOM)

1. INTRODUCTION

The decommissioning of nuclear installations in the UK is a challenge to regulators since it requires the introduction of a regulatory system appropriate to a situation where timescales, organizational structures and public expectations are all changed from those during the operational phase. The flexible, and largely non-prescriptive, UK approach to nuclear regulation has enabled the licensing system, designed for construction and operation of nuclear facilities, to be applied to the very different demands of decommissioning.

2. UK DECOMMISSIONING EXPERIENCE OF LARGE NUCLEAR FACILITIES

The UK nuclear industry has had experience of several small scale decommissioning projects over many years, but the decommissioning of large nuclear facilities is comparatively more recent. These major facilities now being decommissioned include seven gas cooled power reactors, including WAGR, one heavy water reactor, two liquid metal cooled fast reactors and three materials test reactors. In addition, a variety of fuel cycle and nuclear chemical facilities in the UK are being decommissioned. Another major project is the decommissioning of the fire damaged Windscale Pile 1.

3. THE LEGAL FRAMEWORK FOR NUCLEAR REGULATION IN THE UK

The main legislation governing the safety of nuclear installations is the Health and Safety at Work, etc. Act, 1974, and its associated statutory provisions including parts of the Nuclear Installations Act, 1965 (as amended) and the Ionising Radiation Regulations, 1985. Under the Nuclear Installations Act (NI Act), no site may be used for the purpose of installing or operating any nuclear installation unless a nuclear site licence has been granted by the Health and Safety Executive (HSE). Once a licence has been granted, there is a continuing period of responsibility of licensees under the NI Act throughout its lifetime of operation and decommissioning until there is no longer any danger from ionizing radiations from the site. HM Nuclear Installations Inspectorate (NII), on behalf of HSE, grants such licences but safety remains the responsibility of the licensed operator. It is for the licensee to satisfy NII that this responsibility has been fully met.

Although NII is responsible for the regulation of waste management on nuclear licensed sites, discharges to the environment and the disposal of radioactive waste are regulated under the Radioactive Substances Act 1993 by the Environment Agency and the Scottish Environment Protection Agency. Close liaison is maintained between the two regulatory bodies, in addition to specific statutory consultation arrangements.

4. REGULATION OF LICENSED NUCLEAR SITES

The NI Act allows conditions to be attached to the site licence in the interest of safety. Over recent years, the conditions attached to the site licences of all of the nuclear licensed sites in the UK have been standardized. These conditions require the licensee to have arrangements to address the key safety activities associated with all the operations of a nuclear installation, including decommissioning. The regime is flexible, allowing all licensees to develop their own arrangements to best suit their business. Consequently, these conditions apply equally to decommissioning and operating sites and form a continuous process of regulation from ‘cradle to grave’. In effect, they encompass the arrangements for managing safety on the site. A set of 35 conditions is now attached to each licence (Appendix 1). NII reviews the licensee’s arrangements to see whether they are clear and unambiguous and address the main safety issues adequately, and seeks consistency between the assumptions and commitments made in the safety case and the safety management system.

In regulating a site, NII makes use of a number of controls derived from the licence conditions which are all legally binding commitments placed by NII on the licensee.

One of the key requirements is for the licensee to produce adequate safety cases for all operations which may affect safety. From these are derived operating limits and conditions, maintenance and other safety requirements. During decommissioning the licensee is expected to have a safety case justifying the safety of the plant at all times and also to justify the safety of operations which are being undertaken as part of the decommissioning process. The licence conditions also require that the safety case be regularly reviewed.

Another requirement under conditions attached to the site licence is that the operator is required to produce and implement decommissioning programmes. Outline decommissioning programmes should be available for plants at the design stage, and more detailed programmes would normally be produced some time before operations cease permanently. NII has the option of approving these programmes, which then cannot be changed without the approval of NII. In addition, the arrangements for decommissioning should, where appropriate, divide decommissioning into stages, and NII has the power to specify that the operator shall not proceed to the next stage without its consent. These discretionary powers under the licence can be used by NII to give a high degree of regulatory control over decommissioning.

5. GOVERNMENT POLICY

Strategies for dealing with both decommissioning and radioactive waste arisings are reviewed against HSE policy, which was developed taking account of the 1995 UK Government White Paper Cm 2919, which starts with the presumption that "the process of decommissioning nuclear plants should be undertaken as soon as it is reasonably practicable to do so, taking account of all relevant factors". An underlying principle is the concept of 'sustainable development', such that unnecessary burdens should not be left to future generations. In addition, long term storage of radioactive waste should conform to the principle of passive safety. This requires that waste be immobilized so that there is little need of human intervention, such as monitoring or maintenance work, or of services, such as electricity, cooling water or ventilation.

6. DECOMMISSIONING STRATEGIES

Proper planning of decommissioning work, including the identification of priorities, is very important. NII expects licensees to have comprehensive plans which include all the steps needed to decommission a plant, details of the radioactive wastes that will be produced, and the site infrastructure and plants needed to support the decommissioning process, such as radioactive waste treatment and storage facilities. It is important that the key facilities which may be required for the various decommissioning projects are identified, constructed and maintained to make sure they are available when needed.

These comprehensive plans should be contained within an overall decommissioning strategy for the site. Such a strategy would include a justification of the proposed timetables for the decommissioning process and a demonstration of adequate financial provision. Proposals for the decommissioning of a nuclear plant should ensure the safety of people affected by the hazards on the site. The proposals should also ensure that the hazards presented by the plant or site are reduced in a systematic and progressive way to achieve passive safety. Regulatory approval for decommissioning would occur on a case by case basis.

The licensees are expected to keep their decommissioning strategies under review to take account of such matters as Government policies, environmental requirements, safety requirements, the availability of disposal routes for radioactive wastes, the development of new technologies, the experience gained in decommissioning and the financial implications of proceeding on different timescales. These strategies are reviewed by NII quinquennially in consultation with the environment agencies.

The strategies should be attainable and cover reasonably foreseeable closure scenarios and arrangements for financial provision. They should address these matters together with others that the licensee considers appropriate. They should also cover any progress that has been achieved in implementing the strategy and compare future proposed activities against experiences gained from decommissioning already undertaken.

The strategy should also describe the plant to be decommissioned and the options considered for the task. The licensee should give the reasons for choosing a preferred option and timescale and explain how it meets the requirements of Government policy and relevant regulations. The licensee should also identify alternative options in case the preferred option becomes untenable and should specify the time needed to develop them. The provision of adequate arrangements for continued monitoring, maintenance and staffing of the sites should be considered.

The use of public funds for decommissioning requires close scrutiny to ensure that value for money is achieved. A tendency to defer decommissioning and hence defer expenditure could develop. NII must ensure that such a strategy does not lead to greater risk in the interim period or much greater cost in the future. Safety standards or public expectations may become higher with time, thus increasing future costs and perhaps closing some options. Plants will deteriorate and so will be more difficult to dismantle. Proper care and maintenance cost money, not least in keeping a site infrastructure running.

7. DISPOSAL AND STORAGE OF WASTES

At present there is no ILW disposal facility in the UK, and it is now unlikely that one will be available before well into the next century. Although the position is under review, it is apparent that ILW will need to be stored on sites for a number of decades.

It is Government policy that, where it is practical and cost effective to do so, licensees should characterize and segregate radioactive waste on the basis of its physical and chemical properties and store it in accordance with the principles of passive safety in order to facilitate safe management and disposal.

In order to cope with the expected waste arisings from decommissioning it will be necessary for licensees to construct facilities on-site which are fit for the purpose of storing ILW for a long, declared lifetime and should form part of the licensee's decommissioning strategy noted above. The design, construction, operation and eventual decommissioning of stores for radioactive wastes on a licensed site are all subject to the full regulatory control system.

8. LONG TERM MANAGEMENT OF DECOMMISSIONING

In the UK, many decommissioning projects are expected to last for a very long time with significant intermediate care and maintenance periods. Any period of care and maintenance needs to be justified and is only tolerable where there is a clear safety benefit. NII accepts that delay can be justified by an argument that the radiation doses received by staff will be significantly lower if time were to be allowed for radioactive decay, although this does not apply to plants contaminated with plutonium. However, this advantage should be set against the fact that the physical condition of the plant could deteriorate, making the decommissioning task more difficult and hence less safe. If a period of care and maintenance can be justified it needs to be covered by an adequate safety case that identifies the maintenance and surveillance arrangements needed to monitor the safety of the plant. Also, because of the delays in developing a waste disposal facility for ILW, waste stores will be needed for considerable periods of time. Therefore both the licensees and the regulators need to give careful thought to long term management aspects of decommissioning.

NII also needs to be satisfied that licensees have an adequate management structure and resources to discharge the obligations and liabilities connected with the holding of a nuclear site licence over a long period of time.

The continuation of the licensee's financial and managerial capacity to control the site is one of the factors to be taken into account in NII's quinquennial review of decommissioning strategies. It is likely that some of the decommissioning work will be carried out by contractors which may introduce additional demands on the licensee's organization. These general requirements will be less demanding during quiet periods of care and maintenance, but the licensee must preserve the capacity to manage the process of eventual decommissioning.

The licensing regime is based on the premise that the licensee is the user of the site, is in control and is an 'intelligent customer' for services provided by contractors. This will still be necessary during periods of care and maintenance and waste storage. Therefore, the licensee will need to be able to demonstrate that an adequate organization is and will be in place to discharge those responsibilities until the site is finally delicensed and its period of responsibility has ended. To be 'intelligent' means that the licensee must have sufficient competence and knowledge within its own organization to understand the safety features of the plant safety case and to set, interpret and ensure the achievement of safety standards.

The size and skills required by the licensee's organization will vary depending on the state of the plant. During periods of decommissioning work, NII would expect the licensee to have sufficient suitably qualified and experienced staff to control activities, whether undertaken by its own or contractor's staff. A capability to understand the safety case and the significance of any bought-in experience is also required.

The licensee should provide, or have access to, high quality health and safety expertise to provide advice, audit and peer review of safety cases. During care and maintenance the licensee must be able to interpret monitoring and surveillance results and be prepared to take remedial action if required, which may include final decommissioning earlier than expected. Therefore, it may be necessary to expand a small organization fairly rapidly to undertake or supervise work.

The organization will also need a system to retain the corporate memory of the facility if the period of care and maintenance is likely to be prolonged. This will include not only those records required to be kept by legislation but also the local plant knowledge needed to aid later decommissioning. This will reduce the need for a period of research when care and maintenance ceases and final decommissioning begins.

When plants cease operating, they become de facto stores for nuclear matter if they contain contamination or radioactive sludges, dusts or debris. However, the structures have rarely been designed and constructed for such use and may not meet modern standards for nuclear stores. Where reasonably practicable, NII will expect the licensees to make such waste passively safe before any lengthy storage period. Where storage does occur the licensee will need to develop and justify the regime of monitoring and surveillance proposed. This regime will depend on the facility but it will need to be designed to ensure that early warning is given, for example, of structural problems or water ingress. Regular reviews of the safety case for the facility will be required.

The extent and frequency of monitoring and surveillance regimes will depend on the plant concerned. Such features as the number of separate barriers and installed detection or measuring devices need to be taken into account, as does the likelihood of radioactive material becoming mobile. Water ingress from rain, condensation or groundwater can be a particular problem. It has the potential for damaging structures as well as generating mobile wastes from areas of contamination, making the task of final decommissioning more difficult.

The safety case for care and maintenance must be based on the licensee's decommissioning plans and the physical and organizational realities of the site. Safety case assumptions about the form and quantity of radioactive waste and the extent of licensee knowledge and control of operations on the site will be compared by NII with the findings of inspections.

9. USE OF CONTRACTORS IN DECOMMISSIONING

On nuclear sites there are certain requirements which apply specifically to nuclear site licence holders. The key point is that the NI Act requires that the licensee should be the user of the site. NII interprets this requirement as the licensee being the corporate body which is “in day to day control of the site, process and activities and whose staff manage the operation of the plant”.

This requirement is derived from duties contained in the NI Act which stem from the absolute and no fault liability of nuclear licensees to meet (up to defined limits) the costs of any injury to persons or damage to property arising as a result of any nuclear occurrence connected with their licensed sites. Licensees cannot legally pass these liabilities on to others and hence must be able to demonstrate that they are in control of activities on the licensed site. This does not rule out the use of contractors, but in order to be in control, the licensee should be able, amongst other things, to demonstrate the ability to be an ‘intelligent customer’ for any goods or services supplied by others

During decommissioning the licensee may need to contract-in special expertise, and also the quantity of work and hence need for staff varies considerably. There is a tendency to make more use of contractors during decommissioning than during other phases of operation. NII recognises this need and, in principle, has no objection to the use of contractors. However, as explained above, the licensee must at all times be in control of the site because its responsibility cannot be delegated to a third party, and therefore must be able to define, monitor and supervise the work.

10. OPENNESS

It is Government policy to encourage openness in all aspects of health and safety and this also extends to nuclear decommissioning, where many stakeholders can be identified. The licensees’ decommissioning strategies required by the Government white paper are anticipated to be in the public domain, as will be the corresponding HSE report on them.

More direct local contact with the public is obtained via the local community liaison committees (LCLCs) established for licensed sites. Members of LCLCs receive written reports from the NII on a quarterly basis; they attend each meeting. Thus the forum is established to allow open discussion of decommissioning progress and related issues.

11. DECOMMISSIONING ACTIVITIES IN THE UK

A wide variety of decommissioning activities have been, and are being, carried out in the UK under the NII regulatory regime described here. Some research reactors have already been decommissioned to green field sites, and six Magnox power station reactors are currently being decommissioned, as is SGHWR. In addition, the Windscale AGR is being dismantled, and the fire damaged Windscale Pile 1 is also currently being decommissioned.

Several fuel cycle and research facilities are also being decommissioned under the same NII regulatory regime, as are two liquid metal cooled fast reactors. Wherever it is feasible and economic to do so, as much of the clean material arising from dismantling of the plant as possible is being sold on a free release basis or reused on site.

12. CONCLUSIONS

The flexible nature of the UK nuclear regulatory regime has enabled NII to maintain regulatory control over decommissioning both large and small scale facilities without making fundamental changes to the system. Difficulties remain in the area of waste storage and disposal. However, these difficulties can be resolved, provided that public confidence can be maintained. A policy of openness will be essential to achieve this and to ensure public support for safe and timely decommissioning.

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Appendix 1

STANDARD LICENCE CONDITIONS

(1) Interpretation
(2) Marking of the site boundary
(3) Restrictions on dealing with the site
(4) Restrictions on nuclear matter on the site
(5) Consignment of nuclear matter
(6) Documents, records, authorities and certificates
(7) Incidents on the site
(8) Warning notices
(9) Instructions to persons on the site
(10) Training
(11) Emergency arrangements
(12) Duly authorized and other suitably qualified and experienced persons
(13) Nuclear safety committee
(14) Safety documentation
(15) Periodic review
(16) Site plans, designs and specifications
(17) Quality assurance
(18) Radiological protection
(19) Construction or installation of new plant
(20) Modification to design of plant under construction
(21) Commissioning
(22) Modification or experiment on existing plant
(23) Operating rules
(24) Operating instructions
(25) Operational records
(26) Control and supervision of operations
(27) Safety mechanisms, devices and circuits
(28) Examination, inspection, maintenance and testing
(29) Duty to carry out tests, inspections and examinations
(30) Periodic shutdown
(31) Shutdown of specified operations
(32) Accumulation of radioactive waste
(33) Disposal of radioactive waste
(34) Leakage and escape of radioactive material and radioactive waste
(35) Decommissioning

Annex A–13

UNITED KINGDOM — BNFL REACTOR DECOMMISSIONING UNIT (RDU) APPROACH

1. INTRODUCTION

1.1. Background to UK decommissioning

Nuclear power generation in the United Kingdom is dominated by graphite moderated, carbon dioxide cooled reactors. These include eleven stations with natural uranium fuelled Magnox reactors. Of these, three stations are now closed and being decommissioned: Berkeley, Trawsfynydd and Hunterston A. All three of these are twin reactor sites managed within British Nuclear Fuels plc by the reactor decommissioning unit (RDU). This annex describes the arrangements utilized at Trawsfynydd power station.

Compared to light water reactors, the Magnox reactors have large pressure vessels, and the very size of the reactor internals and the external shielding structures means that the scale of decommissioning is large. As such, much effort has been expended to identify an optimum radiological, environmental and financial strategy for decommissioning.

The preferred strategy of the RDU for its reactors is one of ‘safestore’. This consists of the following periods following final reactor shutdown:

First few years	Defuelling and despatch of fuel from site
Project period	Preparation of site for care and maintenance period 1
Project period	Care and maintenance 1 (optional)
Project period	Safestore construction to achieve lower care and maintenance costs
Up to 135 years	Care and maintenance 2
Project period	Site clearance

Each of the decommissioning stations is in the preparation period for care and maintenance 1, having completed defuelling. At Trawsfynydd, local reasons have led to a decision to build the safestore now, but otherwise the same basic approach is being applied, varied to suit local situations.

Regulation of decommissioning stations is undertaken by the nuclear installations inspectorate (NII) by means of the same site licence as for an operating station. This licence has 35 conditions, covering all aspects of a nuclear site from design of new plant to decommissioning (Annex A–12, Appendix 1). The licence requires the licensee to establish ‘adequate arrangements’ for the conduct of the site. For example, licence condition 35(1) requires that ‘the licensee shall make and implement adequate arrangements for decommissioning of any plant or process which may affect safety’. The NII reviews these arrangements to ensure they are satisfactory and may choose to approve them, thus preventing the licensee from amending them without further NII approval. Overall, it should be stressed that the UK regulatory approach is non-prescriptive and approvals are used infrequently by the NII.

Decommissioning generates waste. In the UK, there is an exemption level of 0.4 Bq/g beta/gamma below which material need not be treated as radioactive material and may be freely released. Low level waste (LLW) (<12 GBq/t beta/gamma) can be consigned to the Drigg LLW disposal site in Cumbria, an engineered shallow burial site. Intermediate level waste (ILW) is higher in activity than LLW but not sensibly heat generating. UK Nirex Ltd are charged by the UK government with providing a deep disposal site for ILW, but this is unlikely to be available for use before 2020. In addition, liquid and gaseous discharges are allowed to the environment, to limits authorized by another regulator, the environment agency.

1.2. Structure of this annex

Having established the background within which BNFL operates in the UK, Section 2 of this annex describes the overall approach to liabilities and decommissioning management. The evolving site management approach is developed in Section 3, and actual arrangements currently in use are discussed in Section 4. Finally, the interface with contractors and others so as to ensure safe and economic completion of projects is discussed in Section 5.

2. PRINCIPLES OF LIABILITIES AND DECOMMISSIONING MANAGEMENT

BNFL believes that the management of nuclear liabilities, such as the decommissioning of power stations, needs to be approached as an integrated business stream. This means that late life operation of stations, decommissioning, fuel processing, waste storage and disposal need to be considered as one process as the decisions on one aspect can affect the others. For example, recognizing that a reactor is coming to the end of its life means that fuel loading patterns can be optimized to minimize the unused reactivity in the core.

The cost of decommissioning is spread over many years and a means is needed to provide funds to meet these costs. In the UK, the concept is that funds should be set aside as 'provisions' during the operating life of the reactor. These will be securely invested so that they grow to a sufficient size to meet calls for funds at each stage in the decommissioning process.

In order to optimize the management of liabilities as a whole, i.e to reduce the eventual cost of liability discharge commensurate with safety requirements, BNFL has established within the engineering, waste management and decommissioning division a liabilities management unit (LMU). This unit has accountability for ensuring that business strategies, encompassing technical, stakeholder and commercial matters, are in place to deliver proper control of liability discharge and that these are translated into the business objectives and plans for implementation. It is also accountable for ensuring that the costs of discharging nuclear liabilities are appropriately quantified and identified in the business groups accounts, and that future cash flows are advised to corporate finance to enable proper management of the funds allocated.

The manager of a decommissioning site in BNFL formally seeks expenditure approval to discharge liabilities on his site. There remains the issue of what tasks on the site should be performed now and which deferred to later. In order to provide an auditable approach to such decisions on decommissioning, the following four principles are applied in priority order:

- Safety (is the activity necessary to ensure safety?)
- Environment (is the activity necessary to prevent radioactive leakages?)
- Taxpayer value (does the activity lower the overall lifetime cost of decommissioning in net present value (NPV) terms?)
- Company interests (is there another reason why the company would prefer the task done now?)

Although each task on the site could be considered separately, it is more effective to examine larger scale goals for the site and then, having selected the optimum goal, to examine the contribution of tasks to that goal.

Without such an approach, work may be done early when it could have been done at lower NPV later. Equally, work may not be done, leading to a higher care and maintenance cost until it is done, again raising NPV.

The role of the site manager is to propose what he wishes to do to meet the agreed strategy for the site, justify it in the above terms, formally seek expenditure approval to do it from the business unit executive team (in effect his internal customer); and then achieve his goal to time, cost and quality whilst maintaining compliance with the site licence.

3. APPROACH TO DECOMMISSIONING SITE MANAGEMENT

It is evident from Section 2 that the site managers' purpose should be the identification of a site specific programme to achieve goals consistent with the company decommissioning strategy, and to deliver these goals safely and economically. Unlike station operation management, decommissioning is the management of change, more akin to station construction but with the plant contaminated. However, decommissioning is actually made up of a set of rather different phases. Three, in particular, are worth noting, for they require different management approaches:

I. defuelling;
II. projects on a defuelled site, where some plant operation and maintenance continues; and
III. care and maintenance alone.

There is a tendency to describe decommissioning as the projects aspects of phase (II) alone; this is, potentially, to overlook the underlying infrastructure issues.

3.1. Defuelling phase

In defuelling, which takes approximately two years for a Magnox reactor, the station has ceased generation; there is no longer a marketable product, yet there is much that is similar to the operating period. At first the reactor is simply in a shut down state, similar to an outage. There may be substantial reactivity remaining in the core and the operating safety case remains valid, although with time it may be possible to justify relaxations if criticality can be shown to be impossible.

By the end of defuelling, energetic nuclear accidents are no longer possible and 99.9% of the radioactivity has already left the site. At the closed stations the safety case has evolved through defuelling to release plant, reduce work and accelerate the release of staff.

Early planning for defuelling is essential to make the defuelling project successful and so to minimize the costs of this heavily staffed period. The defuelling safety case should be developed and its implementation planned as far as possible while the power station is still operating. The defuelling period may be time enough to plan the project phase but it is not the time to plan defuelling.

3.2. Projects phase

The projects phase describes that period when the site is undergoing significant physical change. In principle, this could be any time when major work is under way but in this annex the focus is on the ‘preparation of site for care and maintenance period I’ and the ‘safestore construction period’, which are being carried out concurrently at Trawsfynydd. The recovery of operational wastes is being carried out at this time.

There are two distinct aspects to the work. There is the background burden of continuing operations, care and maintenance of remaining essential facilities, plant and systems. There are also the projects to reduce that burden. The former is the management of a repetitive process. The latter is the management of change. It does not seem unreasonable that they require separate attention.

The site manager must be able to show compliance with the nuclear site licence, environmental standards, etc. In addition, the project manager must conduct his activities in accordance with industrial safety regulations. The site manager must be clearly in control of the site. The project manager must be released to achieve his project goals of time, cost and quality. A key requirement is therefore to ensure an effective interface between process and project.

3.3. Care and maintenance phase

At the entry into a long term care and maintenance state, the site is only performing a low level of routine activities. Hazards are small, there should be a limited emergency plan, there is no novel or project work, and staff numbers are correspondingly small. It is appropriate to introduce a step change in the management philosophy at this point.

Overall management of the site still needs to be performed by a suitably qualified and experienced person. It is most likely that such a person would require little time to discharge these duties. Thus it would be appropriate to manage the site centrally, probably as part of a group of sites under one manager.

Equally, there would be scope to provide at least some site services via a mobile team. This would ensure adequate skill levels in those doing the work.

4. ARRANGEMENTS FOR MANAGING A DECOMMISSIONING SITE

As an example of the BNFL-RDU approach to decommissioning site management, there follows a description of the approach to the management of Trawsfynydd power station, a station in the later part of the projects phase.

4.1. Quality management system

In order to ensure maximum likelihood that the site will achieve the goals set for it by the company, the company requires each site to establish a quality management system (QMS) in accordance with IAEA Code 50-C-Q.

The aim is to use the QMS to manage the site's business as a whole. The QMS exists to provide assurance that:

- regulatory requirements for quality, safety and environment will be met;
- company requirements will be met; and
- business objectives will be achieved.

The QMS exists at the highest levels of a decommissioning quality assurance programme (DQAP) which fulfils the following roles:

- states the site manager's QA policy;
- describes the QMS as a whole, including the need for review and audit;
- defines the site organization and responsibilities within it;
- describes the management of documentation including the key area of records;
- states the approach to controlling decommissioning and other modifications;
- describes other support activities.

The DQAP is implemented by management control procedures (MCP), which are based on company models for licensed sites. The model MCP titles are listed in Table I, and these would be supplemented by those necessary to control finance and other business matters.

4.2. Management organization

Each decommissioning site has a decommissioning site manager. He is accountable to the head of the RDU for the safe and economic conduct of the site. This accountability is monitored by the LMU.

For a site in the projects phase, there is a need to manage the effective operations, care and maintenance of the site as well as the more visible decommissioning projects. The organization for Trawsfynydd power station is shown in Fig. 1, extracted from the DQAP. Project (and contract) management is in the hands of specialists in that area. Operations and maintenance are performed by another group. A team headed by the decommissioning site manager defines safety, environmental and business standards for the site and monitors the achievement of these by staff on site, corrective actions being applied as necessary.

TABLE I. TITLES OF MODEL MANAGEMENT CONTROL PROCEDURES

MCP 1	Allocation of responsibilities for compliance with the nuclear site licence conditions
MCP 2	Form and content of site documents
MCP 3	Document control
MCP 4	Graded application of quality assurance
MCP 5	Management of site records
MCP 6	Quality assurance review and audit
MCP 7	Arrangements for dealing with organizational interfaces
MCP 8	Establishment and use of the site plant and apparatus inventory
MCP 9	Identification and labelling of items and systems
MCP 10	Selection, qualification and training of staff
MCP 11	Significant operational activities
MCP 12	Establishment of the operational state of plant and apparatus
MCP 13	Surveillance and routine testing of plant items and systems
MCP 14	Safety
MCP 15	Management of nuclear fuel
MCP 16	Management of solid, liquid and gaseous waste
MCP 17	Environmental management
MCP 18	Operational experience feedback
MCP 19	Management of maintenance work
MCP 20	Work control system
MCP 21	Control of modifications and experiments
MCP 22	Control and calibration of measuring and testing equipment
MCP 23	Procurement of items and services
MCP 24	Material and spares control
MCP 25	Control of security and access
MCP 26	Contingency and emergency arrangements
MCP 27	Good housekeeping
MCP 28	Management of computer systems
MCP 29	Management of safety cases

The organization in Fig. 1 is independent of the number of staff on- site. The functions are required for any site though the means of discharging them may vary with site and workload. Regular meetings to examine site performance, audits and post-project reviews all contribute to effective integration of the functions to deliver the site goals.

The issue of staffing is perceived as very important by the regulators. There is a potential conflict between the utilities that drive to reduce costs by reducing staff and the regulators' concern for the loss of human defence in depth and what has been called 'site memory'. Staff numbers need to be a consequence of change rather than a cause of it.

As the hazard reduces, the safety case for the site can be simplified. This allows a reduction in the demands of site nuclear safety rules, instructions, testing and maintenance requirements. The site QMS can reduce in size with these changes, and the organization and staffing will follow. The need to anticipate the human resource issues associated with reducing staffing means that these issues may become a leader of change but they must not get out of phase with the other changes.

The nature of site staffing is flexible. It could largely be members of the original site staff or, at the other extreme, it could be largely contractors. At Trawsfynydd power station, company staff from the Berkeley headquarters provide project management support via internal contract arrangements. The decommissioning projects are performed by external contractors managed by our project management specialists. Care and maintenance activities are largely carried out by retained operational staff. The station management team are a mixture of ex-station staff and some headquarters support staff.

Many of the persons now working on the site from other departments or contractors were previously employed by the station in operation, i.e. site memory is maintained.

The staffing arrangements are somewhat different at the other decommissioning sites. At Berkeley power station, only a small staff has been retained. All the work is managed by the headquarters specialists, with operations and maintenance activities overlapping with the headquarters staffing arrangements. At Hunterston A, the station has inherited staff with project management skills; this site is self-sufficient, letting external contracts itself.

5. MANAGING INTERFACES — CONTRACTORS AND STAKEHOLDERS

The use of external contractors to perform a large percentage of the work on-site can cause the NII some concern over where responsibility lies. As such, the QMS includes requirements on the management of interfaces in general and contracts in particular.

It is essential that the safety of the site clearly remains in the control of 'the licensee'. Much of UK law demands this, and the NII demands demonstration that it is so. The documentation on larger contracts will be supplemented by an interface document to define the QA processes to be met, the responsibilities of each party and the approved lines of communication.

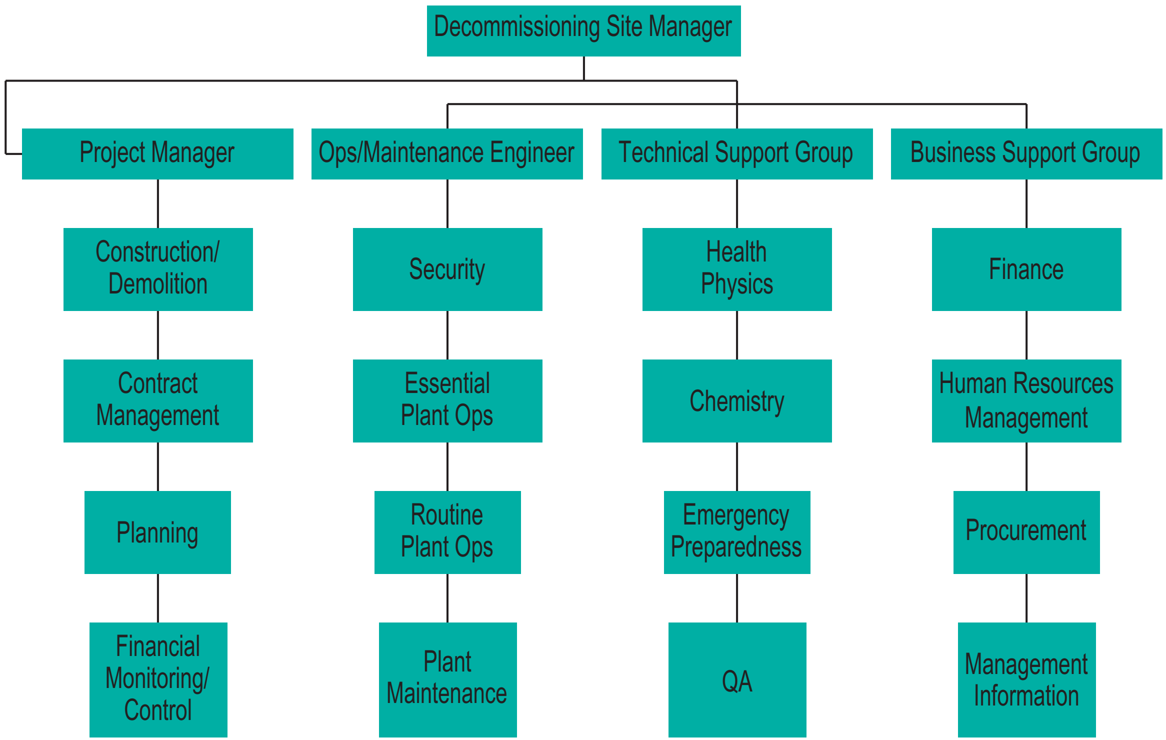

FIG. 1. Trawsfynydd decommissioning site.

Although the contractor needs to be constrained for safety, there are cost advantages from a flexible approach. The practice in letting contracts is to use a competitive tender process with a specification aimed at the goal, leaving the tenderer to offer his route to that goal. This encourages initiative from the tenderer and perhaps the identification of a lower cost approach, not previously obvious to the site owners. In this way, appropriate financial risk is transferred to the contractor, e.g. should his technique lead to programme delays or escalating costs, they are clearly his responsibility. Where an area is novel, it can be reasonable to let one or two trial contracts to establish the financial risks from the task before both sides commit to the whole job. These approaches have proved successful in decommissioning contracts.

A final, key aspect of site management is that of gaining the acquiesence or support of stakeholders — those with some interest in the site. Obvious stakeholders include the UK Government who owns BNFL, local communities, the environmental movement and the public at large.

BNFL pursues an active policy of open communication. By providing information on decommissioning matters, the commitment of the company to safely and economically discharging its liabilities can be appreciated and the company should be able to pursue its business effectively. A range of information routes to the public are used: visitor centres, regular local community meetings, newsletters, press releases, etc.

6. CONCLUSIONS

The BNFL plc philosophy and approach to the organization and management of decommissioning have been described. This is built not only on many years of experience of operating nuclear reactors but also on some eight years of experience in the management of decommissioning power stations.

Annex A–14

UNITED STATES
(PRESSURIZED WATER POWER PLANT)

1. GENERAL

The subject plant is a nuclear powered electricity generating facility consisting of one Westinghouse designed pressurized water reactor (PWR) rated at 490 MW(e). The plant is not co-located with any other facility or plant. The owners of the plant considered the DECON and SAFSTOR decommissioning alternatives. The DECON alternative is the prompt dismantling of the entire facility after final plant shutdown. SAFSTOR is placing the facility into a safe condition and waiting for a period of time (20–40 years) before dismantling takes place. On the basis of a number of factors, the owners decided on the DECON or immediate dismantling alternative.

One of the main factors that affect the decommissioning decision making process is the disposition of the spent nuclear fuel. The United States currently does not reprocess its spent fuel and does not have a permanent repository. It was decided by the utility management to maintain the fuel on-site until the US Department of Energy would accept it. There were four alternatives considered:

- Leave the spent fuel in the existing pool and use the existing pool support systems;
- Leave the spent fuel in the existing pool and use a modified (skid mounted) support system;
- Move the fuel to an on-site dry storage facility; or
- Move the fuel to an on-site wet storage facility.

The owners decided to look at two options: use the existing pool with modified cooling systems and a dry storage facility.

Another factor affecting the organization of the utility staff during decommissioning is the following: the utility does the majority of the activities or acts as an oversight organization and allows a general contractor to perform the decommissioning activities. There are pros and cons for each option but it was decided to have a general contractor perform the activities. This means that the utility staff would be smaller than in the case where they would perform the decommissioning activities themselves.

2. STAFFING DURING DECOMMISSIONING

A site specific utility staff was developed for the management of the decommissioning operations. The purpose of this staff is to oversee the decommissioning operations and the general contractor activities. While this staff is not responsible for the actual decommissioning activities, the utility (the licence holder) is still ultimately responsible for the decommissioning. The utility will operate and maintain the plant systems, monitor the decommissioning operations, provide assistance to the general contractor and otherwise exercise its responsibility as the licensee.

The life of the decommissioning project was divided into nine periods which correspond to major activities during the project and require different staffing levels. These nine periods are:

Period 1 - Planning and licensing before shutdown

Period 2 - Transition period and removal of pressure vessel
Dispose of old waste
Remove all non-essential systems
Modify the spent fuel pool cooling system

Period 3 - Decontamination of containment building
Remove essential systems
Remove steam generators
Decontaminate reactor building
Begin moving spent fuel to dry storage

Period 4 - Remove auxiliary buildings
Remove all auxiliary building systems
Decontaminate the buildings

Period 5 - Remove structures

Period 6 - Restore site

Period 7 - Dry spent fuel storage

Period 8 - Decontaminate and remove dry spent fuel storage facility

Period 9 - Final site restoration

Decommissioning planning (Period 1) will be performed before shutdown. It is anticipated that a utility staff level of 7.5 will be dedicated to this effort. Decommissioning activities will begin immediately after shutdown, Period 2. The staff level during this period will be 125. This level is required to support the vessel and internals removal effort. Also during this time, the spent fuel pool systems have not been modified and require a larger staff.

At the beginning of Period 3 the spent fuel pool systems will be modified, allowing for a reduction in the utility staff. Also during this period, the reactor building essential systems will be removed and the building decontaminated. These activities will control the level of the utility staff. A level of 61 will be required to support the decommissioning operations and monitor the spent fuel pool.

Coinciding with the end of Period 3 is the completion of the spent fuel transfer to dry storage. With all of the spent fuel in dry storage during Period 4, the auxiliary building systems will be removed and the building decontaminated, requiring a utility staff of 56. Also during Period 4, periodic shipments of spent fuel will be made to the DOE. Once all of the residual radioactivity is removed from the site, the staff can be reduced to 29 for Period 5. This staff size is sufficient to support clean structure demolition and monitoring of the dry spent fuel storage facility. The staff is further reduced to 22 during Period 6 when the site restoration is occurring along with monitoring the spent fuel storage facility. In Periods 5 and 6, an additional staff of 8 will be required on-site approximately three months each year to assist the utility staff in preparing spent fuel for off-site shipments. The staff is further reduced during Periods 7, 8 and 9. Figure 1 provides a summary of the utility staff requirements.

The general contractor is not anticipated to have any role in the maintenance or surveillance of the spent fuel pool or required systems during the fuel storage period. His responsibility will be to provide a turnkey decommissioning project. He will be responsible for all activities from initial planning through final site restoration. The general contractor will perform the actual decontamination and dismantling activities under the guidance of the utility staff. During the planning and preparation period the general contractor will have a staff of 22 people on-site to manage and develop the engineering programme. During Period 2 the general contractor staff will increase to a maximum level of 80 people during the vessel and internals removal. This staff will be reduced to 49 for Periods 3 and 4 for essential system removal and structure decontamination. This level is sufficient for the reactor building and auxiliary building systems removal and building decontamination. With the completion of the radiological decommissioning activities, the general contractor staff will be reduced to 32 for clean structure removal and then to 20 for site restoration.

Figure 2 provides a proposed organization for this project. This is a basic organization which provides flexibility and allows proper control. As the decommissioning activities are performed, the organization will grow smaller and positions will be combined.

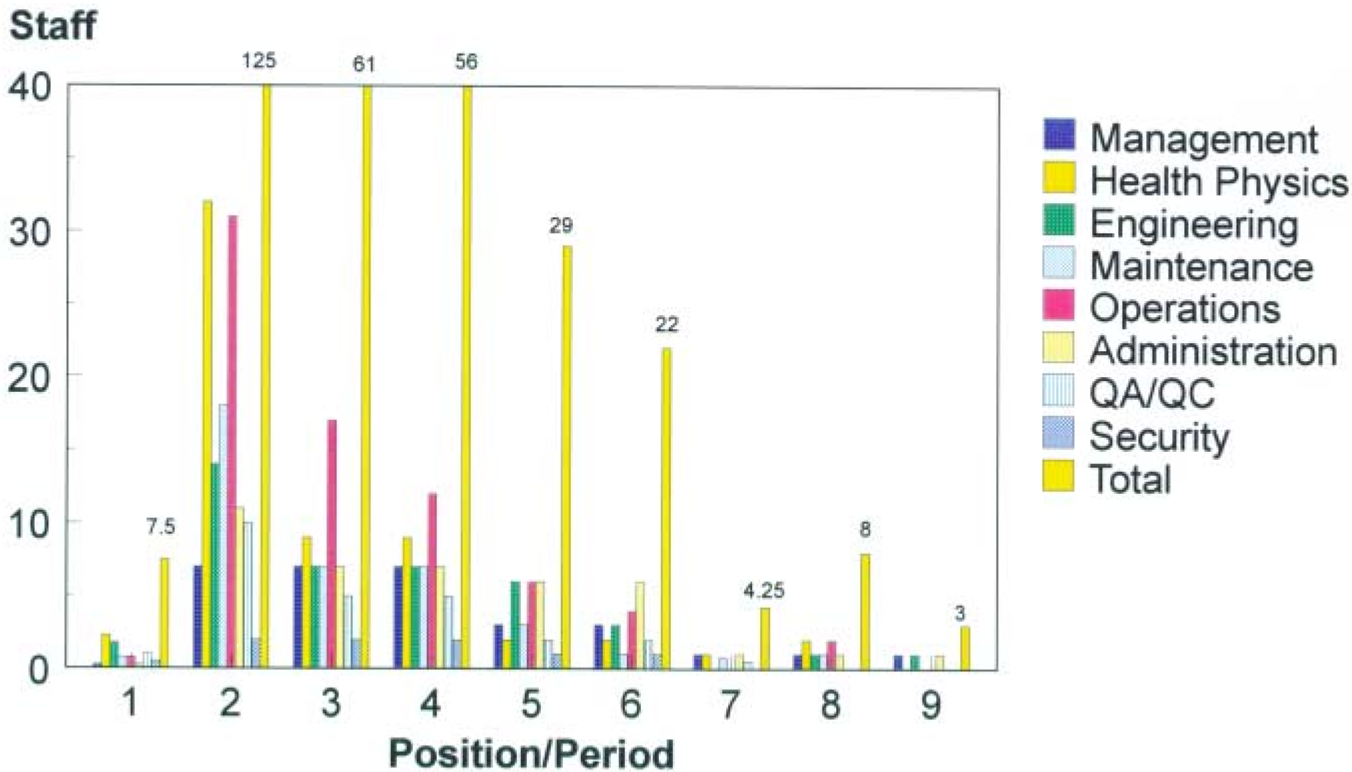

FIG. 1. Utility staff summary.

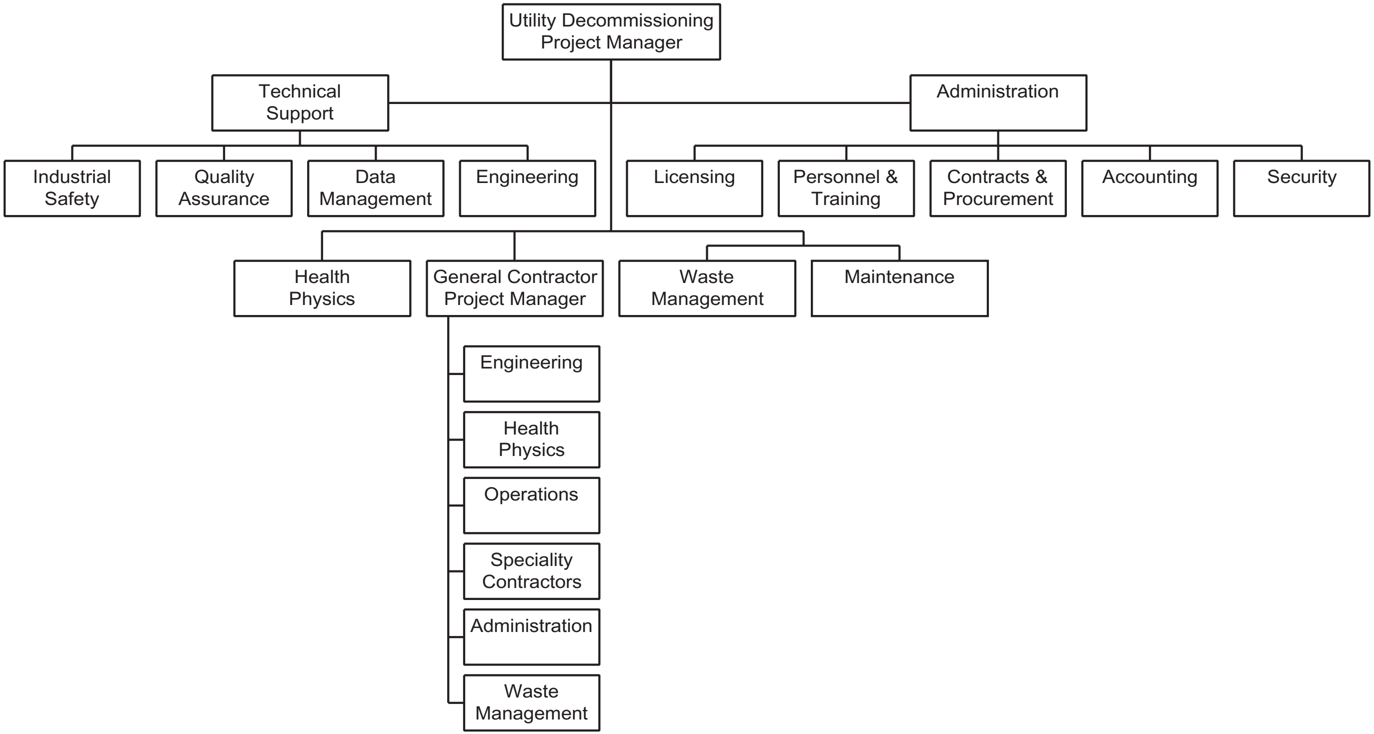

FIG. 2. Project organization.

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