Radioactive Waste Management and Decommissioning
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Preparing for Decommissioning During Operation and After Final Shutdown

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Radioactive Waste Management and Decommissioning

Preparing for Decommissioning During Operation and After Final Shutdown

NEA No. 7374

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The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally sound and economical use of nuclear energy for peaceful purposes;

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Foreword

The transition from an operating nuclear facility to the implementation of the dismantling phase is critical in every decommissioning project. A number of organisational and technical modifications are needed to adapt the facility so that it can meet new objectives and requirements. A variety of activities need to be planned and performed both to support the transition and to prepare the dismantling of the facility.

Experience has shown that it is essential to start with preparations for decommissioning at a very early stage, at best already during the design stage of the facility, and at least during the operational stage. The preparation of the transition to decommissioning and dismantling (D&D) is a key issue for the success of the global D&D project in order to minimise delays and undue costs; to optimise personnel and other resources; and to initiate preparatory activities for decommissioning in a planned, timely and cost-effective manner, with the overall objective of ensuring safe and efficient decommissioning.

With a growing number of nuclear facilities reaching the decommissioning stage, the Working Party on Decommissioning and Dismantling (WPDD) formed the Task Group on Preparing for Decommissioning during Operation and after Final Shutdown (TGPFD), which involves regulators, nuclear operators and independent experts who review strategic aspects to optimise preparations for decommissioning from the last years of operation onwards.

The present report summarises work carried out by TGPFD between March 2015 and December 2017. It supports ongoing and new decommissioning projects by providing observations and recommendations relating to the development and optimisation of strategies, as well as plans to prepare for the decommissioning of nuclear facilities. In doing so, it ensures value for money, safety of workers and improvements in project management consistent with good practices and the timely delivery of decommissioning targets.

Rather than providing detailed descriptions of the relevant methods or technologies, the report focuses on strategic approaches, different issues that might arise, risks and observations of good practice.

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Table of contents

List of annexes

List of figures

List of abbreviations and acronyms

ALARA	As low as reasonably achievable
ALARP	As low as reasonably practicable
ASN	French Nuclear Safety Authority
BWR	Boiling water reactor
CANDU	Canada Deuterium Uranium
CEA	French Alternative Energies and Atomic Energy Commission
CNL	Canadian Nuclear Laboratories
CNSC	Canadian Nuclear Safety Commission
CSA	Canadian Standards Association
CSN	Spanish Nuclear Safety Council
D&D	Decommissioning and dismantling
DECON	Immediate dismantling option in the United States
DETEC	Department of the Environment, Transport, Energy and Communications (Switzerland)
DQAP	Decommissioning quality assurance plan
DQO	Data quality objectives
ENSI	Swiss Federal Nuclear Safety Inspectorate
GTCC	Greater-than-class C
IAEA	International Atomic Energy Agency
IDP	Initial decommissioning plan
ILW	Intermediate-level waste
INB	Regulated nuclear installation
ISFSI	Independent spent fuel storage installation
LILW	Low- and intermediate-level radioactive waste
LLW	Low-level waste
MOU	Memorandum of understanding
NDA	Nuclear Decommissioning Authority (United Kingdom)
NEA	Nuclear Energy Agency

NPP	Nuclear power plant
NRC	Nuclear Regulatory Commission (United States)
OECD	Organisation for Economic Co-operation and Development
PSDAR	Post-shutdown activity report
SAFSTOR	Safe storage, deferred dismantling (United States)
SAT	Systematic approach to training
SCA	Safety and control area
SFP	Spent fuel pool
SSCs	Structures, systems and components
TGPFD	Task Group on Preparing for Decommissioning during Operation and after Final Shutdown (NEA)
VLLW	Very low-level waste
WPDD	Working Party on Decommissioning and Dismantling (NEA)

Chapter 1. Introduction

The preparation for decommissioning and dismantling (D&D) is a key issue for the successful conduct of a decommissioning project; to initiate preparatory activities for decommissioning in a planned, timely and cost effective manner, to optimise personnel and other resources and to plan dismantling activities. All these aspects contribute to ensure the safe and efficient decommissioning of a facility, and to minimise delays and undue costs.

A set of strategic decisions needs to be taken early in the preparatory phase. These decisions are mainly driven by the anticipated end state of the decommissioning project (continued regulatory supervision, e.g. on a multi-facility site or release of the site from regulatory control with or without restrictions on its future use) and culminate in the choice of the decommissioning strategy to be followed. This choice is made between either immediate dismantling (DECON option in the United States) or preparation of the facility for deferred dismantling (SAFSTOR option in the United States).

The approach to decommissioning strongly hinges on internal and external factors which are key enablers or constraints for a decommissioning project and may include:

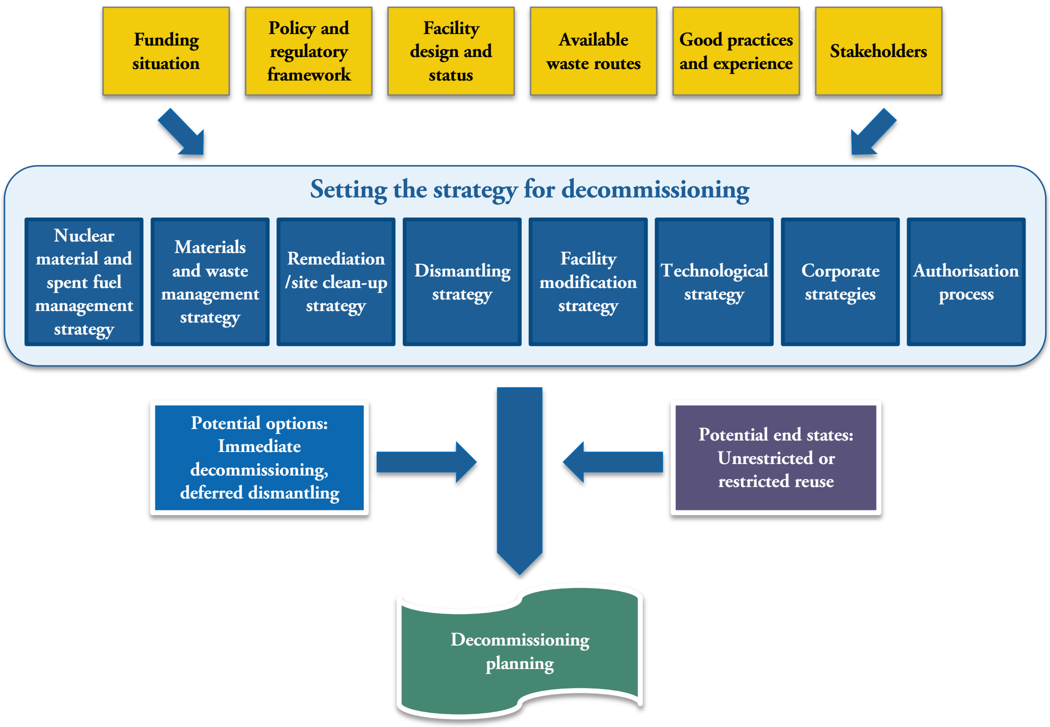
- the funding situation;
- the policy and regulatory framework;
- the facility design and status;
- the available routes for the radioactive waste;
- good practices and experience;
- stakeholder perceptions.

The strategic decisions that must be taken in relation to these key enablers and constraints include:

- the nuclear material and/or spent fuel management strategy;
- the materials and waste management strategy;
- the remediation/site clean-up strategy;
- the dismantling strategy;
- the facility modification strategy;
- the technological strategy;
- corporate strategies;
- the authorisation process.

Figure 1.1 illustrates the key enablers, constraints and strategic decisions leading to the chosen decommissioning planning, which forms the basis for initiating the planning of preparatory activities.

Figure 1.1: A top-level overview of key enablers, constraints and strategic decisions influencing a smooth transition from operations to decommissioning, and the decommissioning planning



As a number of changes need to be initiated to prepare the facility for D&D, preparation for transition from operations through to decommissioning should be started as soon as possible. It is considered good practice for the preparation of this phase to start well before cessation of operations. Ideally, decommissioning should already have been considered during the design stage of the facility, although this requires anticipating a given situation decades ahead. As a consequence, the knowledge relevant for decommissioning bears substantial uncertainties during the design stage. Preparations for decommissioning require active monitoring and tracking of the internal and external constraints in order to gradually decrease the level of uncertainty of knowledge relevant to decommissioning, and the level of uncertainty during facility operations and after commencing dismantling activities, as outlined in Figure 1.2, to increase the maturity of the decommissioning planning.

1.1. Objective

With a growing number of facilities reaching the end of their operational stage, it is important to gather and consolidate experiences available in NEA member countries on the topic of preparing for decommissioning during operation and after final shutdown.

The objective of this report is thus to inform decision makers in decommissioning, decommissioning planners, as well as regulatory bodies, on the key aspects of such a "transition" and of preparing for decommissioning during the last years of operation and after cessation of operation. The aim is to ensure that these activities begin early, and where possible, during the operational stage. Starting early will ensure that the transition from operation to decommissioning is carried out effectively and efficiently so as to optimise time, and human and financial resources.

The report applies the terminologies as set out in Figure 1.3.

Figure 1.2: Evolution of the uncertainty of knowledge needed during the planning and conducting of a decommissioning project (not true to scale)

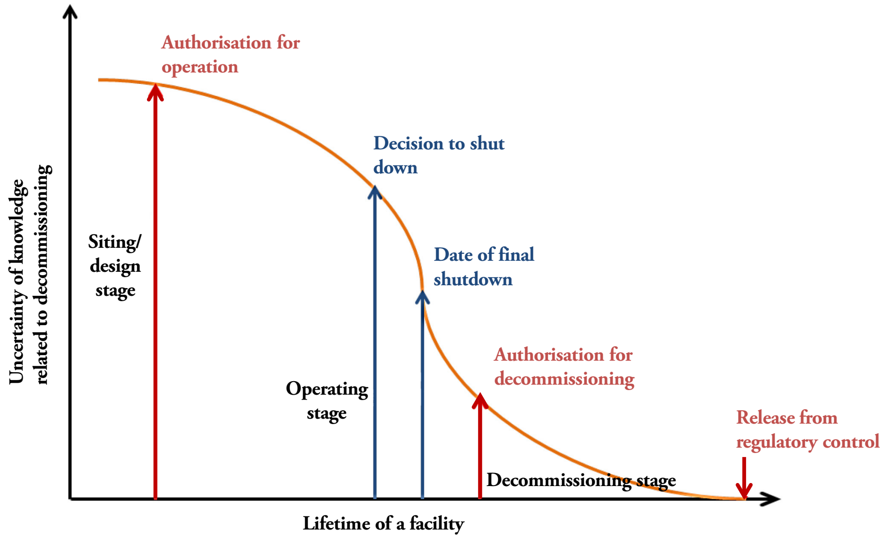
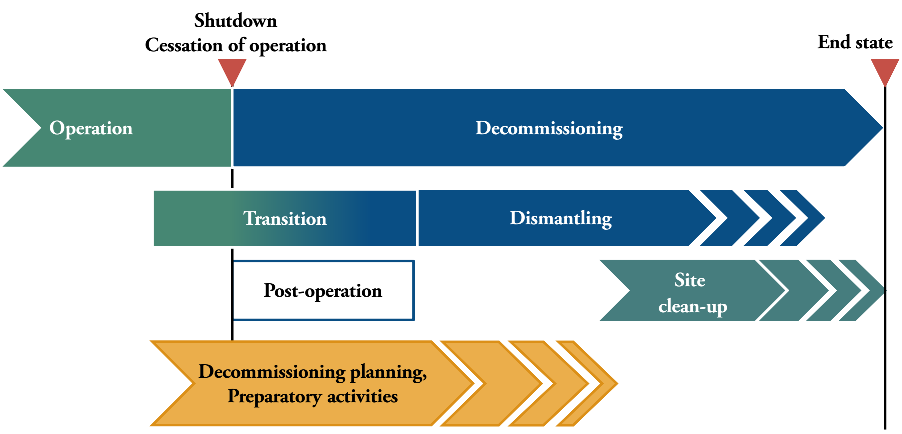


Figure 1.3: Transition in relation to operation and decommissioning



The term "transition period" (sometimes referred to as the "transition phase") is intentionally not used in this report as its understanding and use varies from country to country. Although the term can be found in many national and international documents, and is used in most countries to describe the phase starting with the cessation of operation (final shutdown) and ending with granting the authorisation for decommissioning, or by the date of approval of the final decommissioning plan, this report introduces the term "transition" in order to emphasise the broader character of the considerations, shifts and activities that are involved with the change from operation to decommissioning.

1.2. Scope

This report draws on experience of NEA member countries in preparing for decommissioning and dismantling so as to identify considerations that need to be made, decisions to be taken and activities to be carried out, as well as interrelations between certain aspects and key issues so as to prepare and plan for the decommissioning of a nuclear facility.

It summarises observations, good examples and recommendations relating to the development and optimisation of planning for the decommissioning of a nuclear facility. This, in particular, is in order to support new decommissioning projects. The report focuses on strategic approaches, different issues that might arise, risks and observations of good practice, rather than providing detailed descriptions of the relevant methods or technologies.

The considerations in this report are intended to cover and be applicable to any nuclear facility undergoing decommissioning, although some differences in the planning, preparations and/or procedures may occur for specific types of facilities, such as fuel cycle facilities. Users of this report may select certain parts of this report as applicable to their particular decommissioning situation.

The report mainly discusses the "immediate decommissioning" strategy, but the approach is also applicable to the initial phase of the "deferred dismantling" strategy.

1.3. Organisation of the report

The observations and findings presented in this report are based on the experiences of NEA member countries, as well as on a review of international publications.

The constraints/key enablers and strategic decisions that lead to and set the course for decommissioning planning, which forms the basis for preparatory activities, are described in Chapter 2.

Chapters 3 to 6 provide detailed information on aspects that have been identified as key factors enabling the effective and efficient conduct of a decommissioning project with timely preparation and planning:

- pre-dismantling and post-operation activities;
- regulatory framework and authorisation for decommissioning;
- external stakeholders;
- organisation transition.

Chapter 7 summarises the findings of the report, and the annexes provide further information on individual aspects described in the report, as well as case studies reflecting experiences in individual NEA member countries.

Annex A presents several case studies from different NEA member countries to illustrate aspects related to the preparation of decommissioning and transition.

Annex B highlights the more common contracting models for the supply chain.

Annex C provides a comparative summary of different requirements for decommissioning, preparatory activities and responsibilities in various NEA member countries.

Annex D provides further information on the training programmes of nuclear facilities that are based on a systematic approach to training (SAT).

Annex E contains a bibliography of international standards and guidance, as well as national documents related to the transition from operation to decommissioning.

Chapter 2. Setting the strategy for decommissioning

2.1. Introduction

The focus of this chapter is to define the strategic decisions that need to be taken as part of preparing for decommissioning. These decisions should ideally be taken well before the date of the final shutdown.

Section 2.2 describes the key enablers and constraints influencing the setting of a strategy for decommissioning, and Section 2.3 describes the main elements that need to be addressed in the definition of strategic approaches that form the basis for the decommissioning planning.

The strategic decisions taken are to be reviewed regularly in the light of the overall decommissioning project, its progress and other decisions made and refined or adjusted if necessary.

2.1.1. Implementation of the strategies

Once the strategies have been determined, decommissioning planning needs to be developed that takes into consideration these strategies as a basis for conducting the decommissioning project. This planning should be approved by the responsible organisations and its implementation should be kept under review.

2.2. Key enablers and constraints

A number of key enablers and constraints need to be considered when setting the strategy for decommissioning. These include:

- available funding;
- policy and regulatory framework;
- facility design and status;
- available waste routes;
- good practices/experience;
- stakeholders.

Such key enablers and constraints are further discussed in the following sections.

2.2.1. Available funding

In most countries, mechanisms for providing decommissioning funding are in place and based in national law or regulation (NEA, 2016a). However, different approaches are taken with respect to the way that the funds are accumulated, the level of oversight and the conditions of qualification for funding.

The decommissioning funds might be controlled by a state body or managed by the utility itself.

The availability of the funds has a significant impact on the planning and conduct of decommissioning activities.

For example, when availability of funds is limited, the strategy may prioritise on safety-related considerations, which means activities and projects that reduce the risks to the public and the environment.

2.2.2. Policy and regulatory framework

A variety of requirements need to be fulfilled to obtain the required authorisation to undertake decommissioning activities. Such requirements are defined not only by the nuclear regulator, but also by other authorities focusing on workers' safety, environmental safety, waste management and transportation.

The respective legal and regulatory requirements have to be identified and analysed when setting the strategy. This is critical, as the time for obtaining an authorisation can be significant; it has to be carefully taken into account while preparing for decommissioning in order to avoid delaying the subsequent steps.

2.2.3. Facility design and facility status knowledge

A key part of the transition is the transfer of the facility knowledge from the operation organisation to the decommissioning organisation. The facility knowledge is held by the entire operation organisation and therefore knowledge management is not just about providing layout and drawings of the facility but includes access to any additional records and information that are judged necessary for a detailed understanding of the actual status of the facility. It is important to capture the operational background which includes changes made to the plant design and operational incidents/events that may not be adequately documented within formal records, but instead may be confined into individuals' memory.

In addition, complementary knowledge may be acquired from other internal organisations – such as the supply chain, for example – and therefore learning from their experiences should be part of the strategy.

2.2.4. Available waste routes

Although waste policies exist in all NEA member countries, it is possible that not all waste types are covered. Existing routes for disposal may not be available/compatible to address all the waste categories that are anticipated to be produced through the future dismantling activities.

Ideally, one should secure the necessary waste routes before undertaking dismantling activities. But it is advisable to also consider interim solutions, such as interim storage on-site or using off-site capacities. This approach allows for the separation of the process of generating waste via dismantling, from its transfer to a disposal site, and hence avoids bottlenecking and delays during dismantling operations – due to materials and waste management logistics – and provides more time for establishing missing waste routes for problematic waste streams. However, any measures and approaches should be in balance with avoiding a double handling of waste and potential repacking due to waste acceptance criteria of the repository.

An analysis of available waste routes and opportunities of radioactive waste reduction – such as recycling or clearance, if permitted by the country's regulations – has to be conducted when setting the strategy for decommissioning and reviewed regularly.

2.2.5. Good practices and past experience

Regardless of the level of experience of the team in charge of decommissioning, one of the first activities to be undertaken is to collect the available feedback of experience nationally and internationally. This will help the project team to recognise the critical aspects of a decommissioning project and will provide some benchmarking information.

2.2.6. Stakeholders

Many stakeholders could influence the process of setting the decommissioning strategy or the procedures to receive an authorisation. These include the utilities staff and worker's unions, national and local government bodies, as well as non-governmental organisations (NGOs), regulators (nuclear regulator, environmental protection regulator, etc.), local communities and residents. A systematic and consistent approach is therefore required to ensure that all the key enablers of the project are appropriately identified and information is provided in a timely manner.

A stakeholders' map is presented in Figure 2.1 below. The approach with stakeholders has to be flexible, as there are many variables associated with transition itself.

Figure 2.1: Stakeholders' map: Stakeholders concerned and how they might influence the decommissioning strategy

Stakeholders will have different interests and this should be taken into account in the planned engagement. For example, in most countries environmental aspects will be addressed under an environmental impact assessment which will be discussed with the stakeholders. Local communities may also be concerned, in particular about losing a source of taxes, jobs, supply chains and other socio-economic factors, as well as the foreseen end state of the site.

2.3. Objectives of the strategic decisions

Setting the strategy for decommissioning has to address the following aspects:

- nuclear material and/or spent fuel management strategy;

- materials and waste management strategy;
- dismantling strategy;
- corporate strategies;
- authorisation strategy;
- remediation/site clean-up strategy;
- technological strategy.

Each of these aspects is discussed hereafter and further details are provided in Chapter 3.

2.3.1. Nuclear material and/or spent fuel management strategy

This strategy needs to cover all types of fissile material that may occur in a nuclear facility: spent fuel, damaged fuel and other fissile nuclear material (e.g. in research facilities, reprocessing plants, etc.), as well as non-irradiated fuel (fresh fuel). A major aim during the transition is to remove all fissile material from the facility for two main reasons:

- Reduction of fixed costs: The surveillance of the nuclear facility, which still contains fissile material and/or fuel, causes significant costs in order to maintain all necessary safety-related measures. The removal allows a reduction of the safety and security measures in accordance with the licence requirements. Consequently there is a clear motivation to remove such material from the facility as early as practicable.
- Start of decommissioning and dismantling: In most countries, the removal of all fissile material from the facility marks the end of the transition from operation to decommissioning and is at the same time a prerequisite according to national law for starting the D&D. However, D&D may commence with fresh fuel still on-site.

Strategy for spent fuel, damaged fuel and other fissile material

This strategy has to provide support for the retrieval, management, interim storage or predisposal of such material. This will depend on national policies, as well as the availability of capacities, equipment and casks. Regarding spent fuel the options are as follows:

- sending for reprocessing/recycling;
- storing in casks in an interim storage at the site or an off-site storage facility, for example the independent spent fuel storage installation (ISFSI), to await disposal;
- establish a “spent fuel pool island” (SFP island). The SFP island approach consists of isolating the spent fuel in a self-contained storage area, i.e. existing pool. Such an approach allows for segregation of the area that shall remain in full safety control.

For damaged fuel and other fissile nuclear material, special solutions may need to be developed when options for their handling are not available.

Fresh fuel

In particular, in the case of an unplanned shutdown of a nuclear facility, fresh fuel might be on-site. Available options for the fresh fuel could be:

- reuse in other nuclear facilities;
- recycling in a fuel fabrication.

It is recommended to have plans for the further use of fresh fuel, if it cannot be avoided, as early as possible during the operational stage of the nuclear facility. The removal of fresh fuel from the facility is not a prerequisite for starting D&D.

2.3.2. Materials and waste management strategy

When developing a materials and waste management strategy it is recommended to consider the overall process from generation (during D&D) up to its clearance, if applicable, and/or disposal. A materials and waste management strategy needs to cover all types of materials and waste flow even though certain streams, such as the radioactive or potentially radioactive materials and wastes, will need more attention.

Decommissioning projects are waste driven projects to a large extent. Each and every one of the main steps in a decommissioning project involves or needs to consider material and waste management aspects. The material and waste issues have a strong influence on the decommissioning activities and, in many cases, also the schedule.

When forming the materials and waste management strategy, it is important to identify and secure the potential end states, to have a good understanding of the initial state and, based upon that, plan for the waste routes. The full understanding and consideration of waste acceptance criteria for disposal and, if applicable, the clearance criteria, when planning for and implementing characterisation, decontamination, dismantling and waste treatment, are key success factors.

The strategy should – in line with the above – take into account the presence of potentially recoverable material or equipment (reuse or recycle within or outside the nuclear sector). Most nuclear facilities contain large volumes of material subject to clearance or classified as conventional material.

Other strategic decisions to be taken are:

- the extent of on-site waste treatment;
- localisation of the local waste treatment centre (see also Sections 2.3.5 and 3.6.4);
- contracting the waste handling activities or build an organisation for self-performance.

The decision on the level of on-site waste treatment is closely related to the waste acceptance criteria for storage and disposal, clearance criteria (if applicable), transportation limitations and whether there are service providers in radioactive waste treatment.

Waste management is of such an importance that most national regulations require a waste strategy to be clearly described in the final decommissioning plan (see Section 4.2).

The materials and waste management strategy should address the following:

- inventory of solid/aqueous/gaseous materials and waste (in nuclear and conventional areas of the facility);
- a waste management plan for the radioactive and potentially radioactive waste;
- waste management infrastructure for handling, interim storage and transportation including reviewing the capability of existing on-site treatment facilities and capabilities;
- material and waste disposal routes (and their availability).

The waste management plan enables understanding of the supply chain requirements, as well as facilitating development and implementation of:

- treatment technologies and concepts;

- innovative treatment and packaging techniques;
- new disposition options (reuse, recycling and disposal).

Operational waste

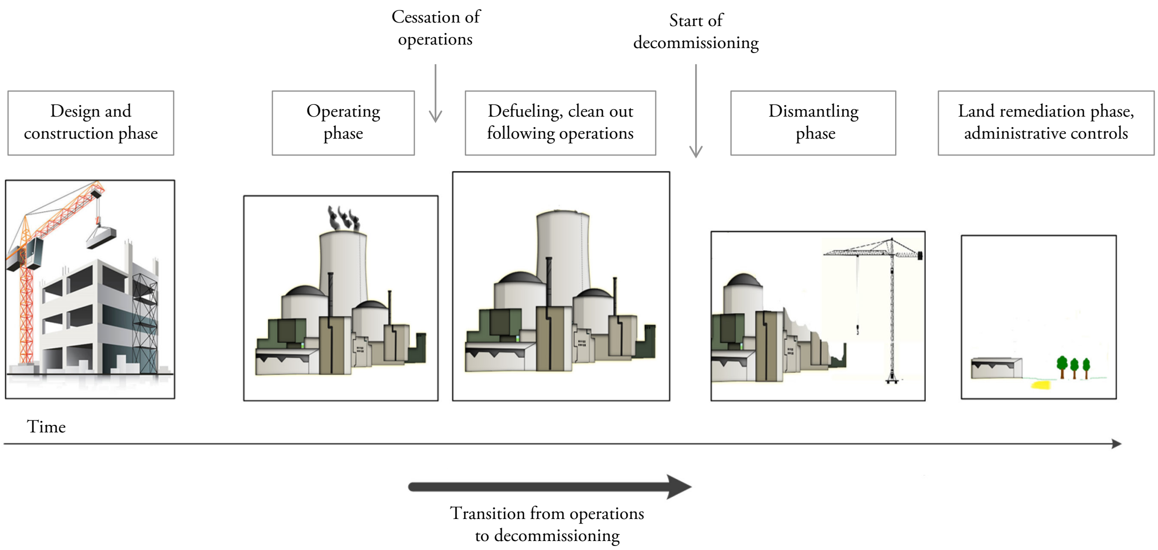
Operational waste, i.e. waste from the operational phase, may be included in the consideration for the materials and waste management strategy, but it is in general recommended to remove most of it during the transition (see Section 3.6.2). Particular attention should be paid to those wastes from operation that occur only in small quantities but are very active – such as calibration sources, detectors and probes.

2.3.3. Remediation and site clean-up strategy

In the context of the life cycle of nuclear facility (shown in Figure 2.2), a critical part of determining the optimal decommissioning strategy is to clearly understand the intended end state that is to be achieved. The end state is the point at which the decommissioning and remediation mission is complete, although there may be a period of institutional control following this point. The end state will be dependent upon local and national factors and in particular what the intended next use is to be for the site, but may not involve the removal of all radioactive material from the site. Therefore, the next use may result in restricted or unrestricted use depending on the nature of the end state and how much material has been removed.

A key component of the decommissioning strategy is consideration of the actions that are required to be taken to ensure that the land itself is suitable for the intended next use and the achievement of the end state. This phase is generally executed in the latter phases of the decommissioning mission and is referred to in this report as remediation.

Figure 2.2: Life cycle of a nuclear power plant as an example of a nuclear facility's life cycle



As part of the optimisation process associated with deriving the end state, it may be determined that although all radioactive material can be removed from the site it may not be optimal to do this. For example, if a site has no identified options for reuse, the removal of all subsurface concrete structures, which will require significant resources, may have no benefit, and therefore does not represent an optimal end state.

The process of justifying the proposed end state will require engagement with many competent bodies, such as environmental regulators, as well as other stakeholders such as the public. The optimisation approach will require the consideration of many factors, such as radiological, environmental and conventional safety, as well as financial and socio-economic factors. The output of this process will be a justification to the competent body – generally the regulators – that the proposed approach has reduced risks (including those associated with radiological and conventional safety) to as low as reasonably practical/achievable (ALARP or ALARA).

Once the end state is clearly understood, the progressive delivery of the decommissioning mission can be expressed by a series of interim states which are typically stable points within the mission – such as the removal of all fissile material from the facility. The use of interim states is particularly useful for a lengthy decommissioning project or programme as they allow focusing on near-term goals which can also be used to inform stakeholders.

The remediation phase is intended to implement measures to ensure that overall radiation doses are ALARA following the end state. The remediation strategy needs to be aware of the initial state to ensure any remediation actions are justified and beneficial. There are several options for land remediation, and these could include in situ remediation techniques such as those employing monitored natural attenuation. As shown in Figure 2.2, after the end state has been achieved and potentially the site is being reused, there may be a period of institutional control for radiological protection which includes controls such as monitoring to determine if remaining contamination is behaving as expected in terms of decay and spread.

The NEA report "Strategic Considerations for Sustainable Remediation of Nuclear Installations" (NEA, 2016b) describes good practice in this area, includes a strategic approach on how to address long timescales involved in decommissioning and remediation, and helps in decision making on site end states and interim states.

2.3.4. Dismantling strategy

The dismantling strategy should consider optimisation opportunities for the segmentation and removal of structures, systems and components (SSCs), which take into account both the physical and the radiological status of the facility at the end of its operational phase or when the dismantling is intended to start.

The dismantling strategy should take into account the following aspects and approaches:

- sequencing of the dismantling, e.g.:
  - "hot to cold" vs. "cold to hot";
  - "room by room" vs. "system by system".
- in situ dismantling vs. rip and ship approach;
- support systems (e.g. replacement of electrical systems, etc.);
- segmentation approaches (e.g. larger parts vs. cutting in small pieces);
- implications for materials and waste management facilities suitable for D&D activities (e.g. logistics, availability and location of radioactive waste treatment facility, interim storage facilities, etc.);
- withdrawal from the facility and site, including decontamination, clearance, demolition or reuse of building or structures.

2.3.5. Facility modification strategy

The facility modification strategy aims to facilitate the overall decommissioning project execution and the dismantling activities and thus may contribute to the reduction of fixed costs. It ensures that the infrastructure and supporting systems (auxiliary systems and installations) of the facility are adapted and provided for decommissioning which:

- commensurate to decommissioning needs, progress and risks;
- allow flexibility to accommodate possible changes during decommissioning;
- reduce interferences between auxiliary systems and installations with dismantling and decontamination activities.

Therefore, it should to be closely co-ordinated with the other aspects of the decommissioning planning and strategy definitions (such as materials and waste management, dismantling, authorisation process, etc.) in order to achieve the decommissioning optimum in terms of time and costs.

For sites with more than one nuclear facility, the facility modification strategy also needs to take into consideration site-specific aspects including, among others:

- necessary decoupling of the facility to undergo decommissioning;
- a site-wide strategy for auxiliary systems and installations.

Auxiliary systems

These systems, mainly for electrical supply, ventilation, fire protection, treatment of liquid effluents, conditioning/processing of radioactive waste, etc., can be either modified and adapted or be replaced by new supporting systems. In both cases, they need to be designed in a way that they fulfil their function, in particular with respect to their safety functions, and do not interfere with the dismantling activities. Good practice in this context is:

- use of modular and mobile systems;
- introduction of wireless systems and new technologies;
- continued maintenance of handling equipment for large components (e.g. polar crane).

It is recommended that the licensee has early engagement with the regulators as changes to systems may require new aqueous/gaseous discharge points.

Auxiliary installations

The following types of areas may need to be created in support of selected strategies of dismantling and materials and waste management: areas for system cutting, conditioning/processing areas for materials and radioactive waste arising from dismantling as well as storage areas for materials and radioactive waste. Taking into consideration the existing infrastructures at the nuclear facility and logistical considerations for tackling the materials and waste streams (see Section 3.6.4) and basing on good practice, the strategy may include:

- To use an auxiliary building for accommodating centralised systems and auxiliary facilities and infrastructures: cutting workshops, decontamination workshops, waste conditioning areas, zone for waste storage, etc. An existing building can be adapted to this function.
- To install confined cutting areas into the buildings to be dismantled.
- To distribute storage areas for dismantled materials and waste along the site.

Further considerations in the development of auxiliary installations strategy include:

- specific requirements for the handling of highly activated wastes;
- buffer storage areas for dismantled materials and waste with sufficient capacities to accommodate large volumes.

Modifications and adaptations in this context should be implemented during the transition as part of the preparatory activities provided they are allowed under the operating licence.

However, it is noted that facility modifications, in particular in case of replacement by a new system or refurbishment of an existing building, may cause additional amounts of materials and waste when they have to be dismantled, and these amounts need to be included in the materials and waste management strategy.

2.3.6. Technological strategy

The technological strategy aims to provide a framework for decisions on the choice of technologies to be deployed and utilised in the decommissioning projects and programmes, taking into account potential needs for and benefits through R&D for decommissioning. This includes fundamental decisions such as whether to rely on proven technologies or techniques (for which performance is better known and predictable), or on innovative technologies or techniques (which may offer significant advantages for its specific use, but for which there are greater uncertainties due to less experience in their use).

Overarching considerations in this context include:

- the need to maintain and enhance decommissioning safety, and to make project delivery more predictable and more efficient;
- the benefits from an early introduction of innovative technologies;
- the knowledge and awareness of (facility-)specific decommissioning challenges which might be better tackled using innovative technologies;
- the given time frame until the technology or technique needs to be deployed.

In addition, there may be significant opportunities to reduce the cost, duration, and environmental impact of decommissioning projects through innovation, provided that adequate lead time is allowed for technology insertion into the project. Final decommissioning plans should, where possible, retain the flexibility for recognition and incorporation of new technologies.

To enable suitable new or innovative technologies to be in place and able to be used when needed, actions will be required preferably before the end of operations, among them:

- identification of areas in an upcoming decommissioning project or in a decommissioning programme with multiple nuclear facilities that may benefit from R&D activities;
- initiation R&D activities in line with the needs of the decommissioning project and fitting into its planned purpose;
- qualification of innovative technologies to prove that its deployment meets the safety requirements;
- interaction with stakeholders involved in the introduction and deployment of the technology, such as the regulatory body.

Areas for technology development include:

- new techniques and instrumentation for characterisation to underpin nuclide vectors prior to decommissioning;

- development of means of deployment of suitable technologies and techniques for decontamination, dismantling and demolition of facilities;
- robotics and automation, including remote handling equipment and systems;
- development of material and waste treatment and/or final conditioning processes.

However, developments and innovations can also address more general and global decommissioning issues such as leaving facility and equipment in place following the operational phase, i.e. a deferred dismantling strategy and whether change in environmental conditions will cause issues for asset management and decommissioning in the future.

The recent NEA report, "R&D and Innovation Needs for Decommissioning Nuclear Facilities" (NEA, 2014), provides an extensive overview and the status in this field and highlights areas with greatest potential for future improvements through research and development.

2.3.7. Corporate strategies

Generally, the licensee (organisation in charge of facility operation) has the responsibility for all aspects of the safe decommissioning of the facility. However, some NEA member countries have specialised organisations which can undertake the entire process (e.g. the Nuclear Decommissioning Authority [NDA] in the United Kingdom and Enresa in Spain).

The corporate strategies should focus on the following, which are described in more detail in Chapter 6.

Organisation

Organisation needs to evolve when transitioning from the operational stage to the decommissioning stage. The first objective of this organisation transition is to ensure that – throughout the transition and the whole decommissioning – an effective and competent organisation remains in place and in charge of the facility.

When responsibilities are transferred from one organisation to other (i.e. from operational organisation to a decommissioning organisation) records of information about the facility should be made available to the successor organisation. The information to be transferred between organisations should be set out in an interface document or contract that describes and specifies the type of the documents and interactions between the organisations.

Human resources strategy

Comprehensive management of former operating staff is a key condition for the success of a decommissioning project. This staff will have to safely operate the facility until the final shutdown and beyond (residual operation) and will also have a key role to play in some of the post-operation activities such as defueling or full system decontamination. At the same time, personnel might be concerned and disturbed by questions related to their own employment (mainly: "what will be my future after shutdown").

Operation personnel's knowledge and experience gained during the operation life of the facility is very valuable for the D&D planning and conduct. Activities such as the removal of spent fuel, primary circuit decontamination and shutdown of redundant systems require the expertise of the facility's operating personnel. At the same time, operating personnel who will continue working during the D&D must be trained with regard to the new risks and the changes that the facility will go through. Decommissioning requires an appropriate mixture of experienced workers with operational memory and new workers with decommissioning experience.

The human resources strategy is to ensure a predictable management of employees with a view:

- to maintain the necessary competences and skills as necessary for the nuclear facility and its remaining lifetime until decommissioning completion;
- to ensure the retraining of employees by anticipating the needs of the site;
- to promote the transfer of skills and also “experience feedback” within the organisation.

Human resources aspects are further specified in Section 6.2.

Governance model and management system

The governance model refers to the mechanisms, processes and relations by which licensees are controlled and directed. Usually the governance model is in place already during the transition and should be considered for establishing the decommissioning planning.

The integrated management system should be adapted to the new stage of the facility. However, management system generic requirements (e.g. document control, work management, change control, assessments and improvements) and management system principles are the same during operation and decommissioning.

Further information is provided in Chapter 6.

Organisational knowledge management

A key part of the transition is the transfer of the required facility knowledge from the operational to the decommissioning organisation. In this context knowledge management is not restricted to the layout of the facility but includes operational records that are judged necessary for successful decommissioning. Attention should be paid to the fact that changes made to the facility design and operational incidents/events might not be adequately captured within operational records.

In addition to the internal knowledge, knowledge can be gained also based on external learning experience. A key lesson from some NEA member countries is that often older facilities are not as well-indicated in drawings, and that modifications have been made during phases such as active commissioning that perhaps were not adequately recorded.

Supply chain strategy

The supply chain strategy needs to define the approach and methods followed when contracting for goods and services for the decommissioning activities. This is a critical aspect for enabling effective delivery of decommissioning activities as the choice of contract negotiated between the licensee and contractors is a powerful mechanism to facilitate delivery of essential goods and services, control costs, and maintain a project within budget and schedule.

Underpinning the supply chain strategy are more fundamental decisions about how the decommissioning project will be managed, i.e. whether this will be undertaken by the licensee as a self-directed project, or managed by a decommissioning operations contractor under the oversight of a licensee Such decisions also have implications for project risk and the choice of contract model to be used. For example, in a self-directed project implementation scenario, the full responsibility of costs and risks lies with the licensee, but for a decommissioning contractor implementation scenario, risk may be shared to a varying degree depending on the contract model chosen. The owner/licensee balances the benefits of putting a contractor at risk, versus sharing the risk to ensure the project is completed successfully.

Accordingly, the supply chain strategy includes decisions on the following:

- The nature of the relationship between the decommissioning organisation and the suppliers of goods and services. This may range from a simple purchaser-supplier relationship, to closer forms of co-operation including partnership in ensuring the effective delivery of the project.
- The choice of specific contract models to be used (some of the more common models are described in the IAEA report *Financial Aspects of Decommissioning* [IAEA, 2005] and an experiences from NEA member countries is provided in Annex B).
- Risk sharing (i.e. between the decommissioning organisation and suppliers of goods and services).
- Performance-related incentives and penalties related to fulfilment of the contract conditions.

Supply chain issues are further discussed in Section 6.6.

Fleet or programmatic approach

For utilities/owners or licensee having a fleet of several facilities, the fleet approach allows optimisation of decommissioning costs in mutualising some phases of the decommissioning projects such as:

- conceptual and basic engineering;
- waste management approach;
- special tools or special process management.

2.3.8. Authorisation process

In line with the requirements of NEA member countries, the authorisation strategy for decommissioning should be determined based on the selected decommissioning strategy. A multi-phased strategy could be adopted in the following cases:

- for large and complex projects;
- in the case when a deferred dismantling is selected;
- when detailed information in support of the final decommissioning plan for the later phases are not yet available.

The licensee should plan during the end of operation or very early in the transition process how to interact with the competent authorities.

The application for decommissioning authorisation should be submitted in a timely manner in order to avoid delays in the decommissioning. For example, depending on the regulatory framework, the decommissioning authorisation application can already be submitted during the operational life of the facility.

2.4. References

IAEA (2005), *Financial Aspects of Decommissioning,* IAEA, Vienna.

NEA (2016a), *Financing the Decommissioning of Nuclear Facilities*, OECD, Paris.

NEA (2016b), *Strategic Considerations for the Sustainable Remediation of Nuclear Installations*, OECD, Paris.

NEA (2014), *R&D and Innovation Needs for Decommissioning Nuclear Facilities*, OECD, Paris.

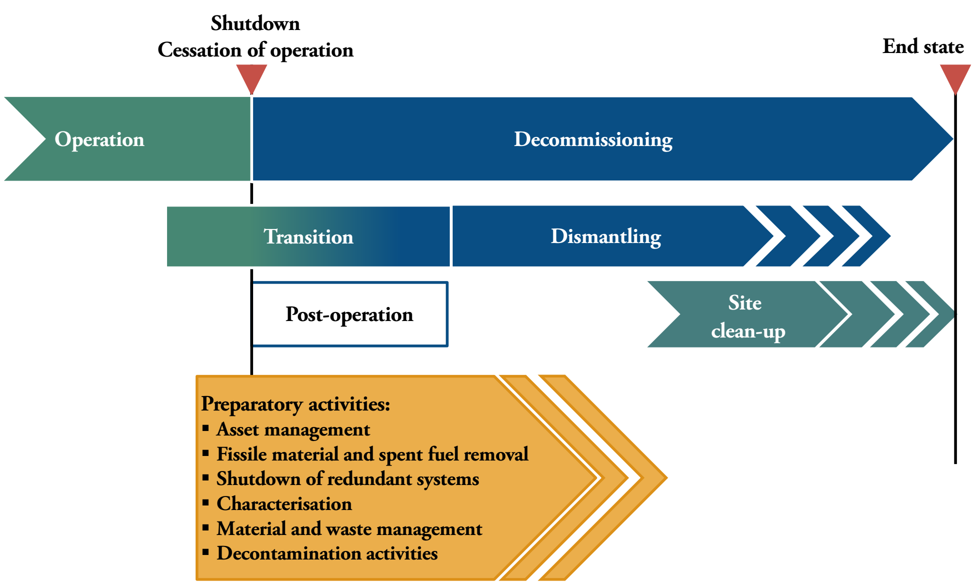
Chapter 3. Technical activities to prepare decommissioning and dismantling

3.1. Introduction

This section addresses a range of key technical activities that may be conducted during operation and after final shutdown to prepare for decommissioning and dismantling (D&D). Such activities supporting the transition from operation to decommissioning are typically performed under the operation licence with its associated safety documentation and technical specifications, and they are usually performed by the operating organisation.

Figure 3.1 shows the typical preparatory activities that aim to reduce the risks or are usually envisaged to prepare for D&D. Annex C provides an overview about what preparatory activities are allowed in various NEA member countries.

Figure 3.1: Typical preparatory activities



Most of these preparatory activities require a great deal of planning and in many cases also engineering activities. In order to facilitate and enable the timely commencement of these activities, most of these planning and other necessary preparations are recommended to be started and carried out in the last years of operation prior to the final shutdown, although some of these activities can only be performed after final shutdown during the post-operation phase. These preparatory activities may continue and be completed in the dismantling phase.

In order to perform these tasks effectively, they need to be underpinned by validated characterisation information supported by an appropriate organisational structure so that knowledge is managed and transferred. In preparing for decommissioning, opportunities can also be taken from a review of the assets, a review of operational instructions and maintenance requirements, as well as exploring technological development including research.

3.2. Asset management

Asset management and investment planning during the final years of operation should consider the full life cycle needs of the asset along with the overall site plan, i.e. understand and reflect the decommissioning requirements, both in needs and in timescales. Clarity of the facility's timeline is a key enabler to making asset investment decisions, whatever the phase of life. This will ensure that the most appropriate decisions are made, mitigating unplanned asset failures by identifying the true lifespan requirements and understanding and managing obsolescence.

Examples of the future asset requirements that should be planned for during the final years of operations are:

- immediate risk and hazard reduction activities after cessation of operations;
- final shutdown of equipment no longer required;
- complex equipment or systems can be considered for replacement by simpler systems more suited to the new demands;
- in case of deferred dismantling strategy, the facility should establish a system for managing equipment ageing.

The conditions of systems needed during the transition and D&D are usually assessed during regular in-service inspections. Knowledge of existing or anticipated obsolescence of systems and equipment should be considered.

For the asset management, it is also important to have an understanding of the operational background of the facility which includes any changes made to the facility design and operational incidents/events that might not be adequately captured within operational records, but instead may be confined to other local records. These may include unofficial records such as those held by the operators themselves within personal notes or their own knowledge. For example, the location of any areas of high radiation fields, damaged areas or items and additional information associated with the operational history and that are vital for the subsequent efficient decommissioning that might be lost with the disappearance of the operating teams. This aspect feeds into adequate waste and operational characterisation during the transition.

Wider site services and infrastructure requirements should be considered to ensure that they are available and maintained for as long as is necessary to support the main facility. There may be a point at which it becomes more cost effective to shut down site services and install local systems instead, e.g. for steam or compressed air (see also Section 2.3.5).

In general, systems can be categorised as: 1) those that are required to continue to operate or need to be modified to support decommissioning; 2) those that can be removed; and 3) those to be installed to facilitate decommissioning. Corresponding activities may follow after the cessation of operation of the facility.

Also the facility maintenance regime needs to be reviewed to reflect the change in focus. This needs to be considered in respect to saving energy, material and human resources while still ensuring that the safety requirements are met. This is particularly important for the deferred dismantling strategy where the facility is left in a shutdown condition for a considerable length of time before the start of dismantling activities. In this case, it is recommended that the licensee performs at regular intervals a review of the facility as a whole. At any time, the facility maintenance has to be carried out according to the requirements of the extant safety case.

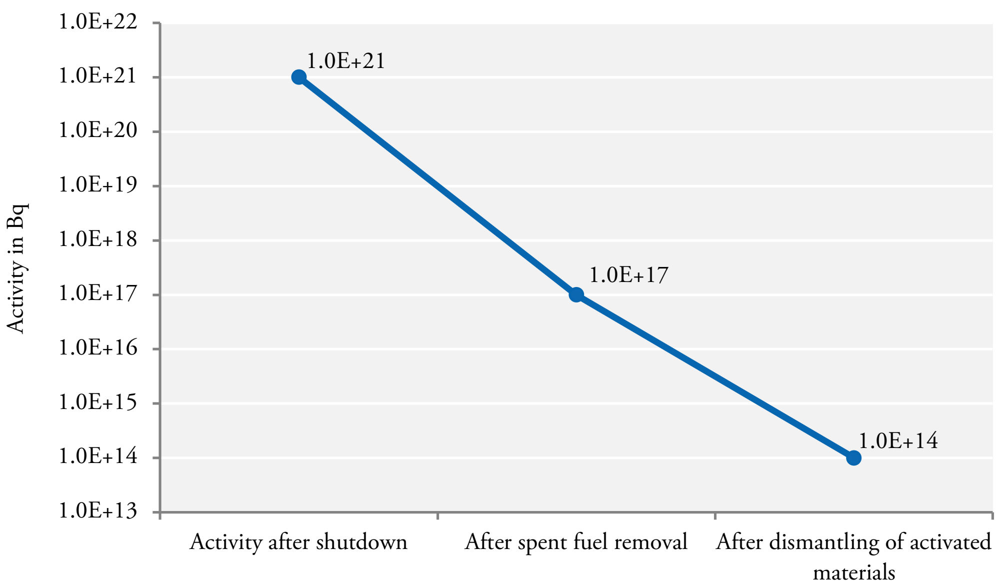
In a nuclear facility undergoing transition from operation to decommissioning, SSCs are being modified and/or retired and their mode of operation may be changing. The operators of these systems need to understand these changes and how they might mitigate any challenges to normal system operation. As such, it is very important that on a continuous basis:

- facility and system drawings are updated;
- system and facility operating procedures are revised accordingly;
- approval and authorisation controls are established and documented;
- scheduling and sequencing of systems to be changed, modified or retired are co-ordinated so as to have no impact on the systems and processes required for operations during the decommissioning project;
- quality controls to ensure the above activities are developed and implemented.

3.3. Fissile material and spent fuel removal

Spent fuel represents more than 99% of the radiological inventory of a nuclear power plant (NPP) and its removal leads to a first significant decrease of radioactive inventory during the decommissioning (see Figure 3.2). The second main decrease of the activity inventory is a result of the dismantling of activated materials, such as the reactor pressure vessel internals.

Figure 3.2: Decrease of a nuclear power plant's activity inventory (exemplary depiction)



Early transfer of the spent fuel to interim storage or an off-site storage facility may facilitate decommissioning activities and significantly contribute to cost reduction, due to the reduced requirements to maintain dedicated resources and facility systems. Therefore, the preliminary activities are:

- unloading of the reactor vessel (hot spent fuel, damaged fuel) in power reactors;

- emptying the cooling pools containing older spent fuel elements (cooled spent fuel) and damaged fuel;
- at other nuclear facilities, removing the nuclear fissile material from the facility storage to an appropriate interim storage.

The removal and transfer of spent fuel are part of standard operations under the operation licence. Where there is no fuel reprocessing facility available or where national regulatory framework does not foresee spent fuel reprocessing, the transfer of the spent fuel to disposal is the preferred option. However, the repositories for spent fuel are not yet available in NEA member countries and thus international practices and approaches vary from country to country, e.g. with respect to their interim storage (see case studies).

If no repository exists, alternative solutions must be studied by the utility such as:

- storage at site in dry conditions (transport and storage casks);
- storage in wet conditions (pool);
- storage in a centralised area.

For other fissile material different solutions may have to be considered taking into consideration the national policies and the condition of the material.

Spent fuel island concept

In order to facilitate removal of SSCs that have formed part of the original facility for spent fuel handling and storage, a decision needs to be taken whether they can be modified to properly cope with the new situation. Some operators have elected to install a completely new spent fuel pool (SFP) support system, sometimes referred to as an SFP island. The SFP island is functionally and operationally equivalent to the original subsystems. However, the SFP island is typically much smaller, because there are lower requirements to manage the heat load represented by the spent fuel as this has already had time to cool and no new spent fuel is being produced. As the SFP support system footprint is a lot smaller than the original plant it is more versatile and therefore can be removed more easily after use. Modified SFP support systems require thorough review and approval before they are put into regular service.

The IAEA safety report, "Safety Considerations in the Transition from Operation to decommissioning of Nuclear Facilities" (IAEA, 2004) gives more guidance on activities associated with safe management of spent fuel at the end of NPP operations.

3.4. Shutdown of redundant systems

Systems that are not required anymore to maintain the safety of the facility can be de-energised or shut down after cessation of operation, i.e. corresponding systems will be switched off and remain unpressurised and cold.

This also includes the drainage of circuits which may reduce the fire load within the facility or reduce the hazards from spills and internal flooding. However, the drainage of circuits may also generate new varieties of waste, which may be different (in volume or chemical composition) from waste known from facility operation. This new waste inventory needs to be included in the waste management strategy and the integrated waste management plan (see Sections 2.3.2 and 3.6).

These kinds of activities are preferably to be planned and carried out by experienced operational staff.

3.5. Characterisation

Characterisation is one of the key activities in decommissioning preparation but also throughout the entire decommissioning project. It plays a key role in providing the necessary confidence and understanding about the initial/current state of the facility. It also provides important input for both the dismantling and waste management planning. A well-performed characterisation supports the "no surprises" outcome, or at least reduced uncertainties, associated with the execution of the decommissioning mission. Characterisation refers to the process of gathering information to support decision making or underpinning of assumptions through the application of measurement or analysis techniques. Characterisation should be based on clear objectives and only be done when there is a demonstrated benefit, i.e. a clear need for information to make decisions, reduce uncertainties or underpin assumptions. Wherever practically possible, data quality objectives (DQO) should be defined.

The outcomes of characterisation are:

- understand conditions of facility – radiometric, chemo-toxic, biological, physical and structural;
- define amount, location and composition of contaminants (radiological and non-radiological) and the associated physical parameters;
- support a categorisation of SSCs and site areas (including ground water) in contaminated, potentially contaminated and non-contaminated areas as a basis for zoning or implementation of a graded approach for clearance.

Good knowledge about the physical properties is important when it comes to decontamination (in situ or during waste treatment) prior to clearance or downgrading from, for example, intermediate-level waste (ILW) to low-level waste (LLW). This is further discussed in the materials and waste management section below.

Categorisation of SSCs and site areas

Prior to implementing the characterisation sampling and measurement campaign for decommissioning, it is recommended to make an initial categorisation of the facility based on the evaluation of available historical information as discussed above. The purpose of this categorisation is to define SSCs and site areas as contaminated, potentially contaminated and non-contaminated. The number and definition of the different categories need careful attention to address the different needs for future work.

Planning and carrying out characterisation

Already during the final years of operation several important characterisation activities can be performed. Typical activities are:

- Determining the volume and the radiological properties of operational waste held up within the facility.
- Reviewing historical information of importance to understand the conditions of the facility and changes in the operational conditions and procedures, which in particular include: operational records, incidents/events and abnormal operation (broken barriers, etc.), and facility modifications like changes in the usage of the facility.
- Assessment of historical characterisation data collection in the light of current requirement.
- Physical inventory of systems and structures.

- Early identification of potentially problematic wastes arising during decommissioning to allow the development of management options so that their impact on the decommissioning is minimised.
- Definition of the chemo-toxic and other non-radiological hazards throughout the facility.
- Characterisation for decommissioning of remote areas not expected to be affected by the remaining operation. Identification of the extent of contamination in soil, subsurface and groundwater is essential for decommissioning planning and therefore collection of the information should be started during the operation of the facility and expanded after the final shutdown.

After final shutdown and especially when all operational waste has been removed further characterisation activities can be performed. The outcome of these characterisation activities is of major impact for the planning of the dismantling and waste management activities. The data, as well as the overall conclusions drawn, play an important role in the planning of other activities like the health physics activities.

It is important that characterisation activities are planned and delivered in a structured way at each step of decommissioning. Characterisation will need to be prioritised with a clear objective and defined output (i.e. doing only the characterisation that is needed and avoiding the temptation to gather additional information that has no clear purpose in order to ensure effective use of resources). Where possible, it is worth integrating characterisation into other tasks, combining different types of characterisation within a single project and making full use of the operational status of the facility. If characterisation activities are planned in parallel, like radiological and non-radiological, they should be cross-checked and combined, if this could mean avoiding double work and resource constraints.

The management of the information is crucial. A qualified database system should be taken into operation early and a quality plan should be mandatory to secure the credibility of the data.

A good co-ordination of the characterisation activities with the decontamination and dismantling planning activities is recommended. A detailed radiological characterisation aiming at detecting very low radiation levels in rooms in which contaminated systems will be exposed during dismantling will partly be a waste of resources.

As well as careful planning and dedicated infrastructure, the different characterisation activities need a knowledgeable staff with the right profile for its implementation. Opportunities should be sought to combine characterisation tasks with other activities. Characterisation information can be gathered during planned inspections and certain activities in areas not accessible during normal operation can be performed during outages.

It is also essential to have a framework in place so that characterisation information is recorded and maintained in a secure, retrievable and understandable manner. Experience has demonstrated that a lack of thorough and validated information will lead to a significant rework and introduce pessimisms and delays into the subsequent decommissioning and unclear safety case requirements.

Definition of nuclide vectors by material source and time

Nuclide vectors, sometimes referred to as “fingerprints” or “scaling factors”, are commonly used to consign radioactive waste for treatment and disposal during decommissioning.

The main objective with the nuclide vectors is to define the relation between easy to measure nuclides like Co-60 and Cs-137 and nuclides which cannot be determined in a simple way (in situ and/or a laboratory environment). The latter can be, for example, low energy betas like Cl-36.

Typically, total gamma or the nuclide specific gammas are measured when waste packages or structures are measured for clearance, to gather transportation information or when waste is qualified for disposal. The other nuclides are determined by correlation using the nuclide vector.

For the decommissioning project, all areas considered as contaminated (i.e. it has a contamination history and is expected to be contaminated) or potentially contaminated (i.e. it can be contaminated but no known contamination) should be sampled to get an understanding of the radiological status. Some of these samples should be analysed for a longer series of nuclides aiming to define or validate the nuclide vectors for decommissioning. For the majority of the samples, less sophisticated analyses can be used. It is recommended to develop specific nuclide vectors for decommissioning. Although these vectors can be similar to the operational ones, experience shows that important differences can occur since operational vectors reflect the current situation of the nuclear facility. Whereas for decommissioning, the various additional aspects have to be taken into consideration when determining nuclide vectors, such as average decay or conditions when historical events took place.

Special attention should be paid to the location of samples and the sampling and analysis process, which involves the necessity of advanced radiochemical analysis.

A way of sampling optimisation should be developed with the aim of saving costs and improving the results. A progressive approach used in Spain comprises:

- Classify the samples by both origin and the simplest or easiest values measured, like dose rate, total alpha or beta.
- For every origin, perform composite samples from the ones that are inside of predefined interval ranges.
- Send for radiochemical analysis the lowest possible number of those composite samples trying to cover a wide range of values and with enough activity to be assured that higher values than minimum detectable activity (MDA) will be obtained.

The definition of nuclide vectors is a very important part of the characterisation for decommissioning. It typically involves non-destructive and destructive sampling, proper analyses in line with defined DQO.

The DQO for individual nuclides may be largely dependent on the further use of the information and the specific end state. Certain nuclides are of large importance for qualifying waste for disposal but are more or less not of interest when it comes to clearance (due to high clearance levels).

Typically, a decommissioning project requires very few nuclide vectors for activated material (if applicable) while contaminated materials, which are distributed over a significantly larger area, may need in the order of ten vectors.

It is likely that additional surveys and measurements will need to be carried out during conduct of D&D in order to reconfirm the validity and applicability of the nuclide vectors or to update them. A typical example when an update of a nuclide vector is needed is after having performed a chemical decontamination.

Further guidance on planning for characterisation is provided by the NEA report "Radiological Characterisation for Decommissioning of Nuclear Installations" (NEA, 2013).

Upon completion of the different characterisation activities the categorisation may have to be updated/corrected.

3.6. Materials and waste management

3.6.1. Planning and preparations

The planning of the materials and waste management strongly hinges on the characterisation (see Section 3.5) with regards to radiological content as well as physical, chemical and, when applicable, biological properties. As discussed earlier in this document, it is of fundamental importance to have a materials and waste management strategy and a waste management plan for the radioactive or potentially radioactive waste (see Sections 2.3.2 and 4.2).

The waste management plan may not be limited to just solid radioactive waste from decommissioning but also waste from residual operation as well as aqueous and gaseous wastes accruing throughout the decommissioning. The decommissioning radioactive waste inventory must adequately identify the quantities and types per category of radioactive waste and potentially radioactive waste that are to be generated during decommissioning.

Through the drainage of the system during the post-operation phase, various liquid wastes are generated that may need special attention. Depending on the type of facility the potentially problematic waste will vary. Common for all types of facilities is that waste with multiple hazards, such as radiological and toxic hazards, should be avoided. If not possible this type of waste should be given special attention. Some reactor types contain large amounts of waste which can be problematic to dispose. A few examples are sodium from fast neutron reactors, heavy water from heavy water reactors and/or graphite from, for example, MAGNOX reactors.

There is a legal requirement in most countries for the licensee (the plant operator) to report, on a regular basis, the inventory of radioactive waste. All countries in the European Union and those who are signed up to the IAEA must provide radioactive waste inventory data.

The radioactive waste inventory data is an important input in, for example, the planning of national repository programmes.

Experience has demonstrated that if a waste management plan (evaluating waste volume, variety, composition, treatment and conditioning) covering remaining operational waste and the forecasted decommissioning waste is developed and implemented prior to final shutdown, there is a greater likelihood that operational waste will be adequately conditioned in time and by then the dismantling not delayed. Furthermore, it will also reduce the risk for delays of the decommissioning due to waste management issues.

3.6.2. Conditioning and removal of operational waste

The conditioning and removal of operational waste is important during transition due to its potential to adversely affect safe decommissioning and to reduce source term/background levels. Removal of most operational waste during transition is recommended in IAEA Safety Standards (IAEA, 2000, 1999a, 1999b and 1999c). But there may also be other reasons and purposes for early removal of operational waste such as freeing up space for buffer storage of waste from D&D.

The objective is to evacuate such waste to a disposal site, including treatment packaging and transportation. The decommissioning project organisation has to ensure that waste generated during preparatory activities, such as decontamination wastes, liquid waste drained from the systems or solid waste as a part of pre-dismantling activities, can be accepted at storage or disposal facilities.

If it is not possible to remove it during the transition, for example because the waste route is not available at that time, it should be stored at a location and in a form with a minimum impact on the decommissioning process.

When operational or legacy wastes are to be managed during the dismantling phase as opposed to being exported during transition or clean-out, the facility operator has to ensure that sufficient information is retained in a retrievable format to provide the decommissioning organisation with sufficient information to make accurate decisions about how to treat these kinds of waste.

3.6.3. Partial dismantling during the post-operation phase

In some countries, piping and system heat insulation is removed early after final shutdown to improve the accessibility of equipment. Although this practice may generate very high volumes of LLW, asbestos or insulating material requiring temporary storage, it is considered good practice as it helps to enhance characterisation of both the insulation materials and the equipment. It may also save time on the critical path which results in cost savings. Similarly, because the risks associated with non-radiological hazards – such as asbestos – do not decrease with time, the removal of conventional waste may result in an overall decrease in risk to facility operators and workers conducting the dismantling activities. Consequently, in some countries, waste containing asbestos, oils or other chemicals is removed as soon as possible from buildings containing radioactive material. A fire protection programme should be implemented for managing the oils and chemicals. After waste removal, the fire protection system needs to be assessed according to the remaining risk and some fire protection features may be retired or require modification.

3.6.4. Logistics of material and waste management

There are many logistical issues with managing the materials and radioactive waste in a decommissioning project. The main purpose of a logistic and waste stream concept is to avoid bottlenecks during the decommissioning caused by dismantled materials and waste that hinder the dismantling activities and thus decommissioning progress.

It is highly recommended to develop a logistic and waste stream concept in accordance with the materials and waste management strategy (see Section 2.3.2), the dismantling strategy (see Section 2.3.4) and the facility modification strategy (see Section 2.3.5). Preferably, and where possible, the planning of the logistics should begin to be explored when the facility is still in operation.

One of the key challenges in materials and waste management is how especially large components and components with high dose rates can be removed. These parameters were not in focus when facilities were designed and built. This causes a number of challenges during decommissioning which may be partly mitigated if identified early.

A basic decision in the context of the logistic and waste stream concept is directly linked to:

- decoupling material and waste treatment from the dismantling activities;
- ensuring sufficient storage capacities including buffer storage capacities;
- definition of a quality standard for the treated waste (in compliance with regulatory framework and the waste acceptance criteria of a repository);
- transport regulations for radioactive waste;
- location of waste and materials treatment (within existing facilities or in a new facility on-site, sending off-site to a specialised facility or centre, fleet or programmatic approach to optimise the location and capacity of treatment facilities).

3.6.5. Waste processing capabilities

Very important input parameters for planning on-site waste processing capabilities are types and quantities, both in total but also per day or week, of radioactive waste that is to be treated and processed. Iteration with the logistics is important to make an overall optimisation.

In order to identify requirements for adaptation/development of the radioactive waste infrastructure, to ensure it is appropriate for the decommissioning need, it is important to understand:

- the radioactive waste management requirements of the programme for forthcoming decontamination or clean-out and decommissioning activities;
- the current capability of the existing waste management infrastructure on the site;
- the available off-site alternatives;
- the available radioactive waste technologies and techniques that may be installed or can be provided by external contractors.

It might be of advantage to share processing infrastructure across a number of nuclear facilities or to use external service providers rather than constructing a facility on each of the sites.

For this evaluation it is important to analyse:

- value of early removal of waste in terms on decommissioning progress;
- overall life cycle costs including investments in buildings, equipment, organisation, etc.;
- decommissioning liabilities for new facilities;
- how an in-house waste treatment facility will affect the decommissioning project;
- transport safety constraints including stakeholders' sensibility on nuclear transport;
- national waste management strategy.

An investment in a separate waste treatment facility will separate dismantling from the waste management which may be a significant advantage for a decommissioning project (see Section 2.3.5).

3.7. Decontamination activities

In some countries, cleaning and/or decontamination efforts have been strongly influenced by the cost of such undertakings. The licensee has to consider performing cost-benefit studies to evaluate the time, capital and resources needed to conduct cleaning and/or decontamination and to determine whether there is a benefit (IAEA, 2004) while ensuring a same level of safety of workers and environment throughout the D&D. In general, the benefits of commencing cleaning and decontamination as early as possible for a facility that has elected an immediate decommissioning strategy are various as they lead to:

- reduced doses for workers;
- reclassification of material and structures;
- reduced efforts in required shielding for dismantling work and associated waste management;
- reduced dismantling efforts, e.g. by enabling work to be performed directly by worker instead of remote controlled works. This may also shorten working time.

Furthermore, performing the cleaning and decontamination shortly after shutdown enables the use of systems and components from operations during and for the system decontamination activities. Whereas, for a facility that has chosen a deferred dismantling strategy, the benefits of a full system decontamination may be reduced, as decay of the site source term during the deferral phase will result in lower worker doses when the active decommissioning is carried out.

Several NPPs have decontaminated the highly contaminated systems (mainly primary circuit) to facilitate D&D operations by lowering the risk of airborne radionuclides, reducing radiation fields and simplifying radioactive waste disposal.

However, attention needs to be paid during the planning of cleaning and/or decontamination to negative side effects or impacts of such activities that may also influence D&D activities later on. Experience has shown that the cleaning and/or decontamination (both radiological and non-radiological) of systems and components during transition may result in unsafe conditions if not properly planned and implemented. Such operations may: i) cause changes in radiological or non-radiological conditions, e.g. displacement of the nuclide vector towards the alpha-branch, resulting in higher than normal exposure or unplanned exposures, or ii) generate flammable, noxious or deadly gases or conditions that may affect workers without their being aware of exposure. To prevent negative side effects, it is recommended that the operator of the facility determines which SSCs can be cleaned and/or decontaminated and when.

3.7.1. Facility cleaning and decontamination

Radioactive inventories in the form of liquid inventories within process vessels and pipework and in the form of deposited and adsorbed solid materials can be found throughout the facility. Facility cleaning and decontamination forms a key part of a facility's hazard management strategy during the post-operation phase, removing inventory so that:

- criticality hazard is removed;
- radiation hazard is reduced;
- no heat generating material remains;
- there is no significant flammable gas generation;
- chemo-toxic hazards are minimised;
- the potential for environmental damage from a leak is reduced;
- dose rates are reduced in areas to limit the need for full remote dismantling and to reduce the dose rates for future decommissioning activities.

3.7.2. System cleaning or decontamination

System cleaning or decontamination de-risk future dismantling activities through reduction of chemo-toxic and radiological hazards. A wide range of risks and operational considerations should be taken into account when developing a decontamination plan:

- justifying doses to the workforce, environment and public and maintaining them ALARP/ALARA;
- ensuring that effluents will be subject to appropriate monitoring;
- ensuring that any proposed decontamination is appropriate and justified based on a balance of benefits versus disadvantages;
- reducing overall facility hazards to enable swifter decommissioning tasks;
- using a delay and a decay approach either for decontamination or for decommissioning activities if the decommissioning timescales allow.

Decontamination activities should be benefit-driven, informed by characterisation and balanced against safety, cost and the potential environmental impact. A cleaning or decontamination plan should be developed that:

- identifies any benefits from the use of novel processes and reagents to deliver the facility cleaning (note that use of new reagents or novel use of existing reagents may trigger the need for regulatory approval or disposal challenges);
- identifies where enhanced cleaning could offer earlier hazard reduction and long-term realisation of efficiency gains and cost savings across the facility life cycle;
- ensures that any effluents generated can be treated using existing facilities, to create discharges that are within permitted limits and meet the regulatory requirements;
- ensures that such activities are not implemented in such a way as to cause unsafe conditions;
- defines a pragmatic balance between trying to get the facility as clean as possible and delivering a reasonable level of risk and hazard reduction for the cost and effort required;
- seeks to effectively remove radiological and chemo-toxic inventory. If possible trial cleaning should be undertaken during plant outages in the final years of operation;
- uses the incumbent nuclear trained workforce, established principles and operating practices, as far as possible, to deliver the cleaning or decontamination goals;
- maximises use of in-house systems and native reagents to deliver process system washouts.

3.8. References

IAEA (2004), *Safety Considerations in the Transition from Operation to Decommissioning of Nuclear Facilities*, Safety Reports Series No. 36, IAEA, Vienna.

IAEA (2000), *Predisposal Management of Radioactive Waste, Including Decommissioning,* Safety Standards Series No. WS-R-2, IAEA, Vienna.

IAEA (1999a), *Decommissioning of Medical, Industrial and Research Facilities,* Safety Standards Series No. WS-G2.2, IAEA, Vienna.

IAEA (1999b), *Decommissioning of Nuclear Fuel Cycle Facilities,* Safety Standards Series No. WS-G2.4, IAEA, Vienna.

IAEA (1999c), *Decommissioning of Nuclear Power Plants and Research Reactors,* Safety Standards Series No. WS-G2.1, IAEA, Vienna.

NEA (2013), "Radiological Characterisation for Decommissioning of Nuclear Installations", NEA/RWM/WPDD(2013)2.

Chapter 4. Regulatory framework and authorisation for decommissioning

This chapter describes the typical aspects of the regulatory process to authorise decommissioning activities. An early engagement of the licensee with the regulatory authority facilitates this process. Authorisation processes potentially have a very significant impact on the decommissioning schedule.

The requirements for decommissioning in various NEA member countries are summarised in Annex C.

To meet the objectives and needs of decommissioning, a number of modifications might be required to adapt the regulatory framework and authorisation process. All NEA member countries contributing to this report have reported having an established regulatory framework for decommissioning. This framework typically requires that the regulator grant an authorisation for decommissioning before dismantlement work can begin.

To ensure successful transition to decommissioning, the following key aspects should be considered:

- An early engagement of the licensee with all regulatory authorities.
- Clarifying the roles of all regulatory authorities involved in the authorisation of decommissioning and harmonisation of regulatory requirements and criteria between them.
- The licensee is responsible for clearly understanding the regulator's expectations for the regulatory process so that regulatory submittals can be made and go through the authorisation process in an efficient manner.
- Both the regulatory authorities and the licensee are recommended to initiate an early engagement of all stakeholders.
- During the transition, the regulatory authorities should adjust their approaches to the changing risk profile during decommissioning and remain flexible to adequately address this change.

4.1. Responsibilities during the transition

Decommissioning of nuclear facilities involves several organisations, the licensee, its contractors, regulatory authorities and governmental institutions. The requirements for responsibilities associated with decommissioning as well as typical responsibilities of each main party involved are described in Section 3 of the IAEA GSR Part 6 (IAEA, 2014). The present report highlights only key responsibilities which are considered vital for a smooth transition.

During the transition to decommissioning, the main responsibilities should be assumed by the regulatory authorities and the licensee:

- The regulatory body should provide proportioned regulatory response by establishing the requirements for the transition to decommissioning.

- The licensee should ensure that the facility is maintained in a safe way at any time.
- The regulatory authority and the licensee should initiate the process of culture changes and/or transfer of responsibilities.

The regulatory authorities and the licensee will also have a role in harmonising the regulatory approach with other institutions (see also Section 4.1.2).

The regulatory authority should establish the safety requirements for decommissioning, including requirements for management of the resulting radioactive waste, and adopt associated regulations and guides. Some key responsibilities are:

- establishing the need and the requirements for a decommissioning authorisation;
- establishing the expectation for the content of the final decommissioning plan and supporting documents (or other submittals) and the process for review or approval;
- establishing requirements relating to the decommissioning of facilities, including criteria for clearance of material from regulatory control, in accordance with national policy;
- establishing requirements and criteria for termination of the authorisation for decommissioning and especially when facilities and/or sites are released with restrictions on their future use;
- providing stakeholders with an opportunity to comment on the final decommissioning plan before their approval, as required by national regulations.

The licensee plans for decommissioning and conducts the decommissioning actions in compliance with the authorisation for decommissioning and with requirements derived from the national legal and regulatory framework. Some key licensee responsibilities concerning the regulatory process are:

- notifying the regulatory body (or the government, if so required) prior to the final shutdown of the facility;
- performing safety assessments and environmental impact assessments in support of decommissioning actions;
- ensuring that properly trained, qualified and competent staff are available for the decommissioning project;
- submitting a final decommissioning plan and supporting documents for review and approval by the regulatory body, in accordance with national regulations, in order to obtain an authorisation to conduct decommissioning.

In relation to preparatory activities (see Annex C), most NEA member countries (Canada, France, Germany, Spain, Sweden and Switzerland) allow preparatory activities under the operating licence, but having some kind of approval or an amendment of operating licence. In France, activities to reduce risk and hazards should be defined and submitted to the French Nuclear Safety Authority (ASN) prior to authorisation for shutdown.

In the case of Spain, an amended of operating licence is required for the post-operation phase. The United Kingdom allows decommissioning activities and preparatory activities under the nuclear site licence conditions and, in the case of the United States, all the pre-dismantling and decommissioning activities are carried out under the operating licence.

In Switzerland and France, some particular preparatory works are possible upon request and in accordance with existing authorisation or permission regulations (e.g. provided by the operation licence), such as installation of decommissioning and supply facilities (but in France it is forbidden to put them into operation) or the dismantling of equipment in the turbine hall.

So as to enable planning and execution of preparatory activities without any approval of decommissioning in an effective way, NEA member countries are advised to have in place and provide an appropriate framework in national regulations and guides, such as definitions for major, minor or preparatory activities.

4.1.1. Authorisation process for decommissioning

Authorisations for decommissioning are granted in accordance with the national legal and governmental framework. All participating NEA member countries confirmed having established regulatory frameworks for decommissioning. Decommissioning is a stage of the life cycle of the facility and the authorisation process for decommissioning should follow the basic licensing principles. A set of requirements to be met prior to authorisation of decommissioning should be established by the regulatory body as early as possible before the post-operation phase.

Depending on the size and the complexity of the facility, the decommissioning may be divided into one or more phases. Each of these phases may be then subject to a separate regulatory approval.

Having an established post-operation phase will help with the adaptation of decommissioning "pre-authorisation" processes, for example, steps of early approval of activities, minimisation of duplication of effort through the different steps and may allow for some steps to be conducted in parallel.

It also provides for a clear division of responsibilities, gives the public opportunities for early participation and ensures that the most important safety issues are dealt with properly in the post-operation phase.

The authorisation process may also include agreements and commitments made between the regulatory authorities and the licensee (e.g. in the form of letters exchanged or statements made in technical meetings). To streamline the authorisation process, memorandums of understanding (MOU) could be signed between the regulatory authorities to address specific cases of overlapping jurisdictions.

In the case of fleet or programmatic approaches to decommissioning, as described in Section 2.3.7, an optimisation of the authorisation process could be considered. The regulatory body and the licensee could agree that the major application documents in support of the final decommissioning plan could be developed at the corporate level and submitted to the regulatory body as common for all fleet facilities.

As the regulatory body's approval of decommissioning activities is of critical importance to the decommissioning, licensees should ensure that regulatory requirements are reviewed and submittals made as early in the decommissioning planning process as possible to facilitate the beginning of dismantlement.

Type of authorisation

Authorisations should cover all stages of the lifetime of a nuclear facility. As such, the decommissioning should be authorised in accordance with the national regulatory framework.

Most countries require a decommissioning licence or some kind of authorisation for decommissioning. In Canada, France, Germany, Spain and Switzerland, a decommissioning licence is required prior to decommissioning. While in Korea, the United Kingdom and the United States, the decommissioning is conducted under the operational licence, which is either amended to modify the conditions or else a specific approval for decommissioning is required. In Sweden, D&D is conducted under the operational licence according to Nuclear Law, but a new licence for D&D is required according to the Environmental Act.

Authorisation time frames

Time frames relating to the authorisation process, the facility status and activities performed at the facilities are not always specified in the regulations and vary from country to country. Most countries use the term “transition period” for the phase starting with the cessation of operation (final shutdown) and ending with the granting of the authorisation for decommissioning or at the date of approval of the final decommissioning plan. Some countries use the term “transition period” to define the period starting with notification of final shutdown, or the starting time of the transition is not specifically defined. In France, the licensee must declare its intention to shut down at least two years before the effective shutdown. Then it has a maximum of two years to submit an application for decommissioning. In the case of the United States, the licensee shall, within 30 days after the decision to permanently shut down the plant, submit a written certification of completing the defueling and permanent cessation of operation to the regulator. Furthermore, the licensee will typically submit a post-shutdown decommissioning activities report (PSDAR) at the same time as the above mentioned certifications, which basically allows major decommissioning activities to begin within 90 days of submitting the PSDAR.

The time frame for authorisation of decommissioning is either defined in the national regulations or established on a case-by-case basis. Some countries, for example France, have established timelines for the deliverables and the approval steps of the licensing process. The decree authorising decommissioning should come into effect four years after the submission of the licence application. In Korea, the licensee should apply for approval of decommissioning within five years of final shutdown. In the majority of other NEA member countries, the authorisation process is rather based on achieving milestone activities and submissions leading to approval of decommissioning than on specific time frames.

In conclusion, there are several time frames for submitting the application documents (depending on the country) such as:

- at the date of final shutdown;
- no later than two years after the final shutdown announcement;
- on a case-by-case basis (no set time frame).

4.1.2. Harmonisation between decision-making authorities

Harmonisation between decision-making authorities (jurisdictions) within the authorisation process of a decommissioning project regard a variety of legal and regulatory aspects, which might be governed by different competent regulatory bodies within a single country. These aspects might comprise of:

- environmental protection;
- occupational health and safety;
- building legislation.

The leading authority, i.e. the nuclear and radiological safety authority, therefore should identify, at an early stage during preparation for decommissioning, the relevant competent authorities. These might be:

- environmental protection agency;
- health authority;

- building authority;
- local authorities.

The leading authority should set up adequate communication channels with all decision-making authorities involved in the authorisation process in order to:

- create awareness of the coming project, scheduling aspects and timescales in order to provide adequate resources;
- clarify the roles, including limitations of each authority within the authorisation procedure;
- inform about the technical aspects of decommissioning in general and with respect to the actual project;
- resolve and/or reach agreement between agencies when criteria differ. These agreements may take the form of MOU signed by the authorities involved.

A formal involvement procedure of the relevant competent authorities is often governed by a procedural step within the environmental impact assessment. This step might also include a scoping procedure, which:

- should be regarded as a consultation appointment between the licensee and the relevant competent authorities;
- might be used to define which environmental impacts need to be assessed;
- is not meant to decide on individual aspects of the environmental impact assessment;
- cannot replace a formal public hearing.

4.2. Application documents and preparation for decommissioning

The specific application documentation to be submitted by the licensee as well as the authorisation process differs in each country. While there is no general consensus on the naming and content of these documents, some general lines of similarity can be found, specifically the information required by the regulatory authorities in support of the approval of decommissioning.

In most countries, the documentation submissions must be reviewed and accepted by the competent authorities prior to the start of decommissioning, while in other cases, some documentation is for informational purposes. A summary of the documentation requirements for authorisation of decommissioning in some NEA member countries is provided in Annex C of this report.

Although the information provided in the application documents varies among NEA member countries, the majority of topics that are covered are common to most NEA member countries. Basic documentation for decommissioning and its content may be the following.

4.2.1. Final decommissioning plan

The initial decommissioning plan, which is required in some countries already as early as at the siting and design stage of the facility's life cycle or at the latest during its operation and which has been regularly updated, forms the basis of the final decommissioning plan. Once a decision to permanently shut down the facility is made, a final decommissioning plan is to be developed and submitted to the regulatory authority.

The final decommissioning plan aims to demonstrate the feasibility of decommissioning in accordance with the radiation protection requirements, estimation of waste quantities, costs and schedules. The detail and complexity of a final decommissioning plan should be commensurate with the complexity of the facility being decommissioned. It should be supported by the safety assessment covering the planned decommissioning activities, and identifying major systems and equipment that may be used during decommissioning.

The final decommissioning plan could be a stand-alone document containing all the information required by the regulatory authorities or supporting documents are to be provided in addition. In some NEA member countries, there is not a specific document called “final decommissioning plan” required, but independent documents are drawn up with specific content.

The final decommissioning plan typically includes the following elements:

- Decommissioning strategy and the rationale for the preferred decommissioning option.
- Regulatory framework and radiological criteria for decommissioning.
- Facility description, site and life history of the facility.
- Description of the initial state and radiological characterisation of the site, including radiological historical data.
- Description of facilities, SSCs needed to perform the decommissioning project.
- General decommissioning project, time frame and end state. Scope of each phase in the proposed decommissioning, if a phase approach is applied.
- Safety assessments and environmental impact assessments, including the radiological and non-radiological hazards to workers, the public and the environment.
- Description of the proposed environmental monitoring programme.
- Description of the organisation and responsibilities of personnel involved in the decommissioning activities, including the number of technical qualified personnel (personnel involved in radiation protection and safety). Skills and qualifications of personnel.
- Description of the quality assurance programme.
- Waste management plan based on the strategy for managing all waste and materials from decommissioning, as described in Section 3.6 of this report.
- A provision of the programme of the final radiation survey.
- Description of the estimated cost of decommissioning and the source of funds.

4.2.2. Safety report

The safety report (sometimes referred to as safety case, safety assessment or safety analysis report) includes the applicable safety and radiological regulations and criteria, as well as the identification and analysis of risks under normal operational and accident conditions, and preventative measures to be adopted. The content of this document may be as follows:

- Safety criteria: radiological criteria for public and workers in normal operation and in accident condition. Radiological criteria for the release of materials, buildings and site from regulatory control according to national strategy.
- Facility description including the radioactive inventory.
- Design criteria, safety functions and their associated SSCs.

- Safety assessment:
  - normal operation (workers and public): radiological hazards and risk assessment;
  - accident condition (public): postulated initiating events and consequence assessment;
- Description of the radiation protection programme.
- Description of the emergency programme.

4.2.3. Environmental assessment

If required by national regulations, an environmental assessment should be conducted prior to developing the final decommissioning plan. The purpose of the environmental assessment is to support the development of the final decommissioning plan by demonstrating that the decommissioning project will not cause adverse effects on the environment. The impact of any mitigation measures that may need to be applied should be assessed in the safety report.

4.2.4. Decommissioning technical specifications

The requirements for technical specifications for some of the safety systems could be downgraded to reflect the risk level of the decommissioning. If there is a significant reduction of safety-related systems, some specifications could be removed.

4.2.5. Regulatory programmes

When not yet included in the safety report, several programmes and concepts providing details on supporting processes for decommissioning performance to ensure the overall safety of a decommissioning project need to be submitted as part of the authorisation process. These programmes include:

- emergency programme: detailing the organisation, responsibilities and measures planned to address accident situations during decommissioning;
- radiation protection programme:
  - occupational: includes the organisation, standards and criteria for radiation protection and protective measures;
  - public: radiological criteria, airborne and liquid releases, monitoring programme and dose calculation to the public;
- quality assurance programme: a description of the quality assurance programme including documentation and record keeping requirements;
- physical security programme, which is confidential and includes measures for organisation, equipment, systems and physical security components;
- materials and waste management programme(s):
  - identification of types, masses and volumes of materials and waste, criteria for segregating materials, type of conditioning for each type of waste, acceptance criteria for storage and disposal for destination according with the national strategy;
  - potential reuse or recycling of materials. Criteria and methodology for clearance materials and buildings according with the national strategy.
- environmental monitoring programme (radiological and non-radiological);
- programme of the final radiation survey (radiological criteria, methodology and equipment to perform the final radiological survey).

4.2.6. Details on financing the decommissioning project

For decommissioning authorisation, some countries may also require an update on the financing situation in order to ensure that adequate funding is available to complete the decommissioning project. Therefore, a detailed cost estimate for decommissioning based on the final decommissioning plan is expected.

4.3. Regulatory oversight

The broad range of safety, environmental and public policy issues that arise in decommissioning a nuclear facility are quite different from those during operation, and they produce corresponding new challenges for the regulator. The regulatory body will want to review its overall staffing and inspection plans for the facility to focus more on the new organisational, human factors and dismantling issues and may augment staff expertise in these areas.

Because of the organisational and human factor issues that will inevitably arise in the wake of cessation of operation of a nuclear facility, the regulator should be prepared to conduct regular inspections to look for possible adverse trends in the overall safety culture at the site.

Since the public health risks posed by a shutdown facility are substantially reduced from those of an operating facility, the regulatory inspection programme should be tailored to address the new regulatory challenges. For example, many of the challenges involve regulatory policy questions rather than operator performance issues. Those regulatory bodies that utilise resident inspectors at operating facilities may want to replace the resident inspectors with periodic team inspections focused on special areas such as ALARA programme implementation, worker radiation protection, site security, operator's contractor oversight, and looking for signs of deteriorating safety culture.

As decommissioning progresses, there may be periods of only routine activities in the facility and the regulatory inspections can be scaled back accordingly. On the contrary, there might be periods with activities in need of an intensified inspection programme, like activities bearing a high radiation risk for the work force or periods with numerous clearance campaigns of materials or site areas.

If the licensee chooses to place the facility in a safe storage mode for an extended period, there will be reduced need for inspections to observe that safety and security systems are not degrading. The regulator should continue to assure that the licence conditions are maintained, including adequate funding for subsequent dismantlement.

4.4. Reference

IAEA (2014), *Decommissioning of Facilities*, General Safety Requirements Part. 6, IAEA, Vienna.

Chapter 5. External stakeholders

The final shutdown of a nuclear facility is often significant in terms of the socio-economic factors. Early and effective stakeholder engagement is mandatory to build trust within the community and establish early confidence in the decommissioning project. A clear definition of the intended interim states and the end state of the decommissioning project is the basis in order to communicate to the stakeholders the strategic decisions taken to prepare for the decommissioning of the facility.

"External stakeholders" in decommissioning projects are manifold (see also Figure 2.1), among them:

- members of the public, directly or indirectly affected by strategic decisions taken;
- (local) government;
- industry;
- environmental interest groups;
- international stakeholders.

A stakeholder information plan should be established, which includes a strategy for the identification of stakeholders and a stakeholder management plan based on a clear communications strategy. Managed and structured communication with all stakeholders will ensure that varying groups of stakeholders are kept informed of the strategic decisions taken to set up the decommissioning project and have the opportunity to provide input to the planning phase. In addition, this approach helps to identify stakeholders that may jeopardise the decommissioning project delivery and timely responses can be therefore be provided.

The stakeholder information plan should foresee public information programmes using different media, like newspapers, brochures, online publications, etc. to:

- inform the stakeholders about the authorisation process;
- inform the stakeholders about the later supervision of the actual decommissioning activities;
- explain technical aspects of decommissioning projects in general and the actual decommissioning project.

Open communication should be promoted and exercised at all levels of the organisation preparing for decommissioning and with all stakeholders as outlined by the stakeholder information plan and associated communication strategy. Working closely with all stakeholders during preparation for decommissioning will build relationships and foster closer understanding of issues, which will, in turn, facilitate more effective and closer interactions to resolve issues as they arise. This approach ensures that the quality of the decommissioning project planning will be improved. As part of the wider communications strategy, communications would be expected to cover aspects such as:

- management policy, objectives and strategy;
- the management system and associated processes and procedures for conducting decommissioning activities;

- the current status of decommissioning planning and waste management activities;
- technical and quality issues (e.g. problems having long-term implications and their resolution, planned improvements and innovations);
- radiological issues (e.g. trends in doses and in releases to the environment, evaluation of accidents and other incidents);
- regulatory and statutory issues;
- present status of the facility;
- health and safety issues;
- environmental, security and economic impacts of the decommissioning activities;
- changes in management arrangements and the continuity of responsible management;
- maintenance of adequate financial resources to support the decommissioning activities;
- opportunities for, and results from public involvement in decision making;
- responses to questions and concerns.

These measures might also be useful to prepare for the public hearing to be held as a formal step within the authorisation process if such a hearing is required by national law or subordinate legislation.

Nevertheless, it is also important to clearly explain that stakeholder engagement is limited and that the licensee, who is bearing the responsibility of conducting a decommissioning project according to the regulatory requirements, has the right to take decision in their entrepreneurial responsibility (no representative participation without accountability).

Chapter 6. Organisation transition

The objective of the organisation transition is to ensure that a suitably competent corporate organisation is established in order to safely execute the decommissioning project.

This chapter describes various organisational changes that are recommended to be planned and implemented during the transition of a facility from operation to decommissioning. In addition, it describes which main measures and procedures of the operational stage need to be reviewed and adapted in order to follow, respond to and support D&D.

6.1. Introduction

As procedures for maintenance, radiation protection, operation, engineering, supply chain, administration, waste management, performance improvement organisations, etc., differ from operation to decommissioning, a change in the organisation is required that is foreseen to implement the chosen strategy for decommissioning.

The intended decommissioning organisation structure should be clearly defined by means of an organisational chart, which can be used to clearly describe the key positions, management units and their respective interfaces. The responsibilities for different activities, such as managing the waste, training, assessments, radiation protection, procurement, surveillance, inspection, control of records, etc. are described in this section. The authority held by managers and staff is defined in their respective job description.

The intended decommissioning organisation would be expected to have an integrated management system in place, which includes work management processes that are appropriate to perform D&D activities. For example, the focus of the decommissioning organisation is likely to rely far more on contactors than an operational organisation. During the transition, the required decommissioning organisation needs to be set up in a managed and structured manner.

6.2. The transition in terms of organisational change

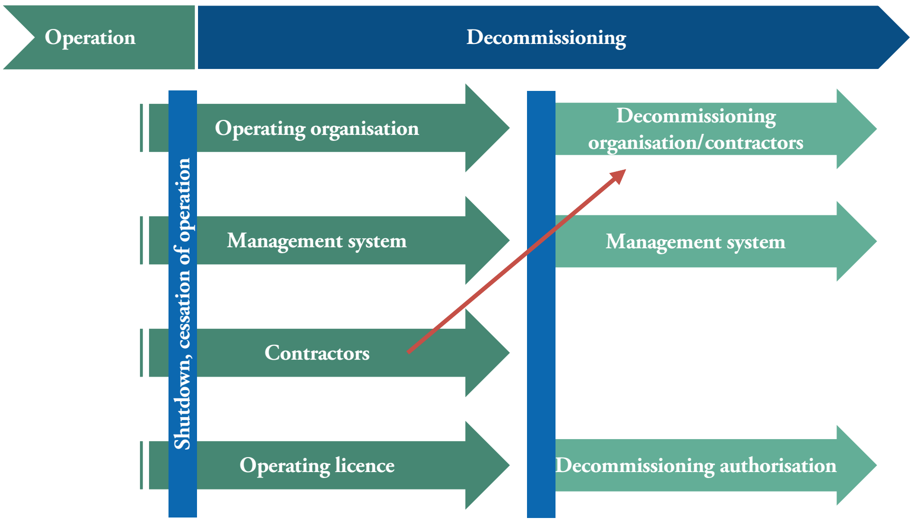
The nature of the organisation transition will itself depend upon the chosen strategies for decommissioning as discussed in Chapter 2. As an example, it might be intended that the organisation that held the licence to operate the facility is chosen to continue through the post-operation phase and to deliver the D&D activities. In this case, the potential overlap between operational and decommissioning functions will need to be managed within the organisation as it is being transitioned.

A more common approach within NEA member countries is that decommissioning is executed by specialist contractors under the oversight of a small management organisation, which generally would hold the relevant authorisation for decommissioning. In this case, the organisation transition would focus on aspects such as the competence of the chosen organisation, its internal processes for the delivery of work and maintaining staff competence, as well as its record keeping in general. The management organisation should keep resources for key positions such as radiation protection and safety, quality assurance, engineering, waste management, project management and maintenance.

There are NEA member countries (i.e. Spain and at some facilities in the United States) where the site licence is transferred to a new organisation. However, there are still contracts with the former operator.

The transition of the organisation has the overall objective of providing an overall organisation capable and competent to execute the final decommissioning plan. The overall organisation could include multiple specialised sub-organisations (e.g. residual operation, radiation protection, engineering, maintenance, etc.). Based on the experience in different NEA member countries, the previous operating organisation should be reorganised and integrated into the overall organisation for decommissioning. The following Figure 6.1 is an illustration of the organisation transition.

Figure 6.1: Typical organisation transition



The decommissioning organisation has to ensure that regulatory requirements are met, that adequate processes are in place to assure and maintain a safe residual operation of the facility and to conduct D&D activities safely and that a sufficient number of qualified workers is present to carry on the decommissioning and residual operation activities.

In the context of the organisation transition there are a number of areas that require specific management to ensure success:

- organisational changes, staff competence and management of resources;
- work control.

6.2.1. Organisational changes, staff competence and management of resources

This aspect is linked to the management systems area, as the skills required are more varied and accompanied by more unknowns and different safety issues (e.g. radiological). In this respect, a decommissioning organisation will feature a management system that assists in driving innovation within a framework of competence assessment.

A significant change to organisational structure and purpose is a stressful time for those within the organisation, and to be successful the process will require careful management to ensure that the required functionality of the organisation is maintained during the transition. A plan to document the downsizing and other changes in the organisation should be created and monitored continually to ensure that the plan is both on track and its objectives remaining valid. The changes to the organisation should be made in accordance with a defined change management process which includes routine stakeholder communication. In order to ensure the adequacy of staffing levels and other functions during the transition, it is important to develop key performance indicators or metrics to help define and measure both performance and organisational effectiveness to enable the prompt identification of any issues or risks that may require mitigation.

Various aspects of the decommissioning stage, such as early analysis and planning or dismantling activities, can be generally subcontracted to specialised companies as required. In this manner, the decommissioning organisation can subcontract some aspects of the decommissioning to specialised firms and companies, and therefore the organisational transition must assess this feature.

The new legal entity charged with delivery of the decommissioning mission will usually (but not always) separate from the previous operational organisation. In some circumstances there may be some operational activities remaining on the site, while other parts of the site are undergoing decommissioning. In this instance, the organisation transition would proceed as normal, but with additional caveats associated with the potential overlaps with operational areas of the site, such as at Sellafield in the United Kingdom. A case study is presented in Annex A of this report.

The competence and leadership of the senior management play a key role in safe and efficient performance of a decommissioning project and as such there should be sufficient oversight of the decommissioning project to ensure adequate corporate performance and not just performance of the decommissioning activities themselves. In this respect, during the organisation transition, assurance needs to be gained that the managers and other leaders in the new organisation have the required competences to ensure that the organisation can both execute its function and drive the required levels of innovation. The competence of the organisation needs to include the ability to adequately oversee the appointment and management of subcontractors required to deliver various specialist phases of the project.

Management resources

Senior management should determine the amount of necessary resources, meaning individuals, infrastructure, information and knowledge, suppliers, material and financial resources. Information and knowledge should be managed as a resource.

It is important that the final shutdown preparation phase allows an optimum preparation of the facility for its decommissioning, taking full advantage of the presence of the operating personnel, with their extensive knowledge of the facility: operating history, incidents, familiarity with the premises and the various equipment items, etc. However, some activities will require outsourcing and/or recruitment.

The number of people involved in the organisation is likely to be reduced in NPP decommissioning projects, usually after the fuel has been removed and primary decontamination has been completed. Different approaches can be adapted to suit the facility decommissioning and take into account the social aspects. If the decommissioning is performed on a site with other nuclear facilities still in operation, there could evolve a situation with a lack of human resources for the decommissioning project in general, since experienced people are usually more attracted to the facility still in operation.

The competences and skills of people required will be different from those in the operation organisation. The variety of skills required for decommissioning is potentially extensive, including remediation/decommissioning projects with several areas such as: safety/security, radiation protection, environmental protection, engineering, construction, maintenance, site clean-up and materials and waste management. This factor influences the reliance on contractors to deliver specialist functions during decommissioning, meaning that the controlling mind organisation needs to be specifically skilful in their management. Thus, in this instance, the focus of the decommissioning organisation will not be on the execution of work, but rather on its management by contract with associated procurement and project management skills. Thus, the availability of qualified and experienced personnel should be addressed by senior management as key for success and should be planned adequately. Maintaining previous operating staff will necessitate that new skills and behaviours are developed.

6.2.2. Work control

The operation organisation will have work control processes suitable for an operating facility. Such processes are generally relatively repetitive, such as fuel loading and maintenance, whereas a decommissioning mission will be associated by a series of "one off" or complex tasks, and as such, the decommissioning organisation should have effective management systems that are sufficiently flexible and robust to manage the safe delivery of a series of different tasks, often using different organisations by means of the use of contractors. It is essential that there is thorough oversight of the whole project as tasks will need to be phased to enable further tasks to be completed. Any slippage in timescales will need to be considered carefully as they will impact on task delivery – it is therefore important to build in some flexibility with contract delivery where specialists are used to deliver tasks.

Every time a significant activity is undertaken, a pre-job briefing should be conducted. This generally contains a quick review of the safety precautions in order to ensure that employees conducting the task are qualified, aware of the risks and that risk is minimised.

Preparatory activities during the transition contain aspects such as changes of the design basis of the facility, removal of fuel, completion of clean-out activities. This includes draining of the systems, final export of fissile material, transfer of waste using extant waste routes, preliminary radiation and characterisation surveys, review of operational records, planning of decommissioning activities, as well as preparation of decommissioning documentation. To ensure transition is effective, changes to the operational documentation may be required. For example, work control arrangements may need to change during transition as more bespoke tasks are delivered.

6.3. Decommissioning project management

In practice, a detailed project schedule must be maintained during transition with sufficient detail and oversight to enable defined metrics and key performance indicators to be measured such that the organisation gains assurance that it is on track to deliver the required outcomes.

Such an organisation normally has a dedicated project controls function within the organisational structure for this purpose, which includes responsibility for the monitoring of performance, deliverables as well as production of the required documentation and other records for the purposes of quality assurance. Planning for the approved projects is accomplished through the gradual implementation of project management documentation. It is recommended to develop a project management plan that would describe the requirements for planning, processes, tools and resources. Work packages are the final outputs of the project organisation. The organisation would provide the control and monitoring of the projects, such as scope, schedule, cost, quality, changes and phase review.

The decommissioning project manager is a key position that should be set during the transition. The decommissioning project manager would be responsible for ensuring that the project is being delivered safely and as expected by the organisation. For this role, project managers should be chosen with previous relevant project management experience in the nuclear environment. An effective project manager should have the following skills:

- technical knowledge of nuclear facilities;
- risk management;
- decommissioning knowledge;
- integration skills.

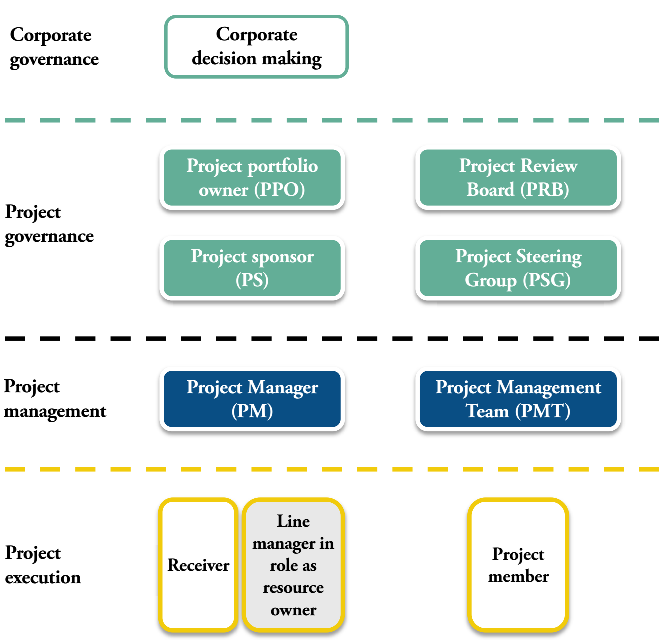
The project team is a combination of the project manager, assistant project managers, functional managers and functional employees. The line managers usually are the technical experts. Functional units, such as engineering, maintenance, radiation protection, contractors, etc. should be integrated and work under the same management system. The line managers are responsible for the resources (human and equipment) used in the project. All these should be reflected in the organisational chart.

Annex A presents case studies related to the organisational project management, in particular:

- France, CEA decommissioning organisation adapted to Grenoble Nuclear Centre Nuclear Decommissioning Organisation.
- Sweden, Vattenfall Ringhals 1 and Ringhals 2 organisational approach for decommissioning.
- UK THORP transition from operations, post-operations clean-out.
- Spain, Enresa, José Cabrera NPP decommissioning.

There are many stakeholders involved in the project. The project roles could be defined in different levels: project governance, project management and project execution. In the below chart (Figure 6.2) is a generic illustration of the governance model used for Vattenfall decommissioning (i.e. the case study from Sweden).

Figure 6.2: Example of a governance model



6.4. Transition risk management

In the transition to decommissioning, risks are managed no differently than for risks associated with the delivery of any project and generally are defined as managing uncertain and unexpected events or conditions, which, should they occur, may have a positive or negative impact on the project outcomes. Risk management is an important function of project management and a key function of the decommissioning project manager, especially for old nuclear facilities. Depending on the project, a risk management document should be initiated.

Good practice suggests that effective risk management is integrated within the project management function. Risk management is an interactive process and involves the early identification of risks followed by the identification and implementation of mitigation measures, the effectiveness of which are continually measured.

The inputs to the process of managing risk are based on information such as records, experience (internal and external), documentation, stakeholder feedback and expert judgement. The risk analysis concerns the operations performed by the operators with the help of the decommissioning project manager. The risk analysis has three principal co-ordinates:

- the state of the archives, documentation and knowledge of the facility to be dismantled (the state as constructed and modified, if necessary; operating history);
- the physical and radiological states of the facilities set at the end of operation;
- the cleanliness of the facilities (presence or absence of historical waste for disposal, best radiological state).

Typical risks associated with decommissioning of nuclear facilities include:

- Poor or incomplete knowledge of the facility (e.g. poor configuration management, loss of documentation and history of facility) leading to delays and additional unforeseen engineering. Mitigation is an effective knowledge management strategy.
- Identification of items of waste with no identified or available waste routes; lack of qualified suppliers and worker shortage.
- Delays related to understanding of regulatory framework, financial decisions and defueling activities.

The organisation, including contractors, could develop sequencing risk process/tools oriented to waste generation reduction, footprint reduction forecast, maintenance optimisation, etc. The process would include the risk factors with direct stakeholder input. Project risk management risks techniques (Nelson et al., 2016) are developed to address the problems with decommissioning of large nuclear facilities.

6.5. Management system

NEA member countries have implemented quality assurance or specific changes to an existing management system during the transition to ensure success. A management system is typically modelled on a standard, which identifies various requirements that facilitate an organisation delivering its assigned mission. A management system integrates many elements of the system, such as human and organisational factors, quality, health, security and economics.

The management system includes processes for the safe and effective delivery of work control, project plans, documentation control, records control, communication, learning from operational experience, establishment and maintenance of organisational competence, training, maintenance of the required safety cases and other assessments, management reviews, problem identification, and resolution and improvement. The management system is based on process view both on core activities of the organisation and supporting processes including managerial processes. The core processes are described by the NEA member countries' regulatory standards and international safety standards, such as (IAEA, 2006).

The organisation should have a management system and leadership that promotes safety. The organisation needs also to consider the new safety issues that will arise from the decommissioning and that were not present during stable and routine operation.

A safety culture action plan could be launched every time a new relevant decommissioning activity begins. Safety culture changes, linked to the organisational changes, should be implemented as necessary.

The management system/quality assurance needs to be adapted to the new stage in the life cycle of the nuclear facility. The management system documentation and implementation for the transition to decommissioning is built on previous implementation of the management system when the same organisation that was involved in operation will also perform decommissioning. The information should be managed to preserve the waste processing, handling and storage, as well as disposal of waste. All relevant documentation retaining the design, construction, commissioning, operation and decommissioning stages of the facility should be retained through the entire decommissioning period.

The integrated management system is designed to manage all decommissioning objectives, adopted standards and stakeholder requirements. An integrated management system is a means by which an organisation, through the systems approach, implements practices that are applied across an organisation to achieve all of its objectives and meet requirements. The IAEA adopted this integration approach to management systems in 2006 (IAEA, 2006). The organisations are benefiting from the integrated approach to manage decommissioning activities by viewing performance against all objectives holistically (EC, 2008).

Sharing the experience among different nuclear facilities, including the competencies, resources, programmes and lesson learnt, will ensure the better planning of decommissioning and lean transition to dismantling. This practice is highlighted by Ytournel et al. (2016).

Some organisations may decide to document the management system requirements for decommissioning by a specific quality assurance plan. The plan is integrated into the overall management system of the organisation. In the case study from Canada in Annex A, this experience is presented. The quality assurance plan herein described constitutes a licence basis document.

All the elements of the management system are important during transition. This chapter describes documentation and record control and training.

6.5.1. Documentation and record management

Under international (IAEA, 2006) and specific NEA member countries' regulatory frameworks, it is specified that documentation be developed and controlled, readable and available at the point of use. The records have to be maintained and the organisation will specify the permanent records in accordance with the licence requirements. Examination of the organisational track record is critical for establishing the decommissioning organisation.

The transfer of necessary documentation, including the operating experience, configuration management, records, documents, etc., should be performed by the new decommissioning organisation or the operator should control those to be used during decommissioning.

During the life cycle of the facility, many documents are created to describe the site and ensure the facility meets defined requirements. Environmental impacts, design basis reports, and safety reports are relevant to decommissioning and dismantling. For the transition, management of knowledge requires the tools (records, archives and repositories) and information management systems (processes). The facility implements the requirements regarding the control and retention of the documentation.

Documents may include policies, procedures, instructions, specifications and drawings, training materials, etc. The document user should have enough information to understand what is available to them so that informed decommissioning decisions can be made. Particular attention should be paid to documents used to control the work processes to ensure that they remain relevant, current, understandable and available to different units (organisations) involved in the project.

The documents should be periodically reviewed as data from internal and external experience is evolving, new research is available or corrections have to be made as a result of the assessments.

The IAEA publication, *Transition from Operation to Decommissioning of Nuclear Installations* (IAEA, 2004) does already conclude that "the availability of relevant data and records is essential for smooth progress into and implementation of decommissioning. A database containing all relevant data needs to be established and maintained. This database should be kept up-to-date through the lifetime of the facility".

During the operation, information is recorded and retained on the physical characteristics of facilities as designed, constructed, commissioned and operated. Design details should include specifications, manuals, drawings and photographs that describe the as-built facility and provide the foundation for configuration control. Records also include data from design changes. For components likely to become activated, material analysis reports, which are useful in defining quantities of trace elements, should be retained.

Prior to the final shutdown, all relevant design, construction, commissioning, operating and maintenance documentation and history should be collected and archived. Records of final shutdown should include the detailed shutdown plans, a description of final shutdown state achieved, and a plan for managing spent fuel and radioactive and hazardous wastes from final shutdown activities. Sources of information to assess the state of the facility after shutdown may include:

- operating history;
- configuration management;
- geophysical assessment;
- operating knowledge of facility;
- investigations;
- non-destructive examinations.

It is recommended to start performing a review (e.g. self-assessment, audit, etc.) of existing records for decommissioning preparation as early as possible. A process to review the relevant archived records and documentation should be implemented. The safety authority could also review the licensee's records.

In the case where the site records or documentation is not available, this will drive increased investigation and characterisation activities. It may also require additional or high levels of personal protective equipment (PPE) to guard against unknown hazards (Nelson et al., 2016).

If the facility will not be decommissioned soon, then the organisation should implement measures to maintain the records for a long time. Inspection of the records should be organised periodically to verify the integrity and completeness of the records and ensure that records are not lost and are still in good condition. If the records are in electronic format, the media should be appropriate to ensure that the records can be accessed over the long term. This could be a challenge as the actual media cannot be kept forever. Additionally, the hardware and software for future reading might not be available. If dismantling starts a long time after the shutdown, this may require updated software or the use of a controlled non-proprietary system/form.

The records should be stored to minimise the likelihood and consequence of loss, damage, deterioration due to unpredictable events such as fire or floods or human initiated occurrences. The storage arrangements should meet the requirements established by the national authorities. If an event occurs that leads to the destruction of records, the status of the surviving records should be examined and their retention might need to be re-evaluated.

6.5.2. Training of staff for decommissioning and dismantling activities

During the transition and implementation of the decommissioning project, there are a variety of skills required as described in Section 6.2.1 (i.e. managers, project managers, engineers, safety managers, technical staff, surveillance staff and transport staff). The training activities should be tailored to the specific competences necessary for decommissioning activities.

The training system provides the basis for the analysis, design, development, implementation, evaluation, documentation and management of training for works at nuclear facilities. With a training system, it can be demonstrated that all required knowledge, skills and safety-related attributes have been attained, through the process of performance-based assessment and programme evaluation.

It is good practice nowadays to develop and implement training systems based on a systematic approach, known as systematic approach to training (SAT) processes, as they are used during operation of a nuclear facility. Annex D describes the SAT process during transition from operation to decommissioning and the experience of NEA member countries related to training. The SAT process also includes training for the new documentation developed during transition.

In the report “Education and Training in Decommissioning Needs, Opportunities and Challenges” (Kockerols et al., 2016), the followings key messages were highlighted:

- Specific attention goes into long-term strategic planning of recruitment and training needs, with an appropriate profile in terms of both time and scale.
- In Europe, there are several training programmes focused on collaborating with industries and co-operating for shared education and training programmes.
- The training programmes include knowledge transfer on specific projects and equipment.

6.6. Supply chain

Various aspects of the decommissioning execution, such as dismantling activities, can be generally subcontracted to specialised companies as required.

The licensee should ensure an adequate oversight of the supply chain management and the major aspects of supply chain management. The oversight should include verification that work is placed with contractors that are qualified to perform the work, assessment and reassessment of the contractor’s management system, records’ maintenance, review of non-conformance, surveillance, inspections, witnessing of activities, review of the contractor's qualifications, review of the organisations' roles and responsibilities, and means to inform the safety authority about relevant information.

The preparation of requisitions and contracts is part of the transition. The contract document issued by the licensee should state the need for a proper quality plan and management system with which any contractor or subcontractor should adhere. The contract could include information about safety, technical requirements, subcontractor obligations, regulatory requirements, hold points, qualifications requirements, right access, change control, documentation and records, etc.

In order to develop the industrial strategy for decommissioning and dismantling and eventually the contracts, the main questions raised by the decommissioning organisation prior to developing the purchasing strategy are:

- Is nuclear decommissioning a growing market; is there a business for everyone including foreign companies?
- Are companies able to invest and is there an opportunity for future market renewal of the nuclear fleet?
- Is the regulatory environment evolving/changing, which will put the operator in a situation to increase the control of the specifications and ultimately the risks provisions?
- Are the contracted companies' businesses at the same level of knowledge, including foreign companies?
- Is it difficult to renew the skills of the participants?
- Is it easy to find dismantling expertise and competences on the market?
- Can risk be transferred or shared?

The licensee should develop supply chain policies. The fundamental elements of the supply chain policy are:

- for complex dismantling operations, it is preferable to involve suppliers on overall global services in order to gain experience from similar activities performed elsewhere and take into consideration that this should be achievable without extra cost for the owner/licensee;
- the risk has to be assumed by both licensee/owner and supplier at the lowest cost;
- the supplier should commit to performance results, combined with cost-plus-incentive-fee related to achieving terms of results;
- motivate the supplier on finding innovative solutions to shared earnings (incentive);
- apply integrated services combining several specialties to reduce the involvement of the owner/licensee in the management of interfaces;
- determine the number of qualified suppliers and the number of affected employees of these companies at the national level for nuclear activities;
- specify the proposed dismantling schedules and potential amounts involved, so that companies can prepare for these markets;
- possess a contracting policy by applying the principle of "best bidder" in the selection of companies (and not the "lowest bidder");
- avoid competing technical offers that are not balanced with respect to these expectations.

Formal requirements for procuring goods and services

NEA member countries developed and implemented a regulatory approach regarding the control of the supply chain for decommissioning projects. The safety authority should verify that the licensee establishes and implements a contracting process that would ensure that all the procured goods and services meet the regulatory requirements. The safety authority should perform compliance activities to confirm that the licensee verifies the performance of the contractor's processes to assure quality and safety.

The typical following supply chain processes are:

- purchasing requirements;
- supplier acceptability;
- provisions of the purchasing requirements to suppliers;
- supplier selection and award;
- supplier-customer relationship and monitoring;
- verification of services;
- receipt and inspection of items;
- disposition of problems.

NEA member countries implemented measures to verify the contractor's activities (technical and quality). For example, in France, in order to ensure the quality of execution of clean-up and decommissioning of nuclear facilities, which it entrusts to the contractor companies, in 1989 the CEA implemented a mandatory acceptance procedure. Only a company that meets the CEA requirements can be included in the call for tender for decommissioning services.

6.7. References

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Chapter 7. Conclusions, observations and recommendations

The transition from an operating nuclear facility to the implementation of the dismantling phase is critical in every decommissioning project. A number of organisational and technical changes and modifications are necessary to adapt the facility so that it can meet the new objectives and requirements. A variety of activities need to be planned and performed both to support the transition and to prepare the dismantling of the facility.

Preparations for the transition to decommissioning and dismantling (D&D) is a key issue for the success of global D&D projects so as to minimise delays and undue costs; to optimise personnel and other resources; and have preparatory activities initiated early so that decommissioning takes place in a planned, timely and cost effective manner to ensure safe and efficient decommissioning.

7.1. Conclusions and recommendations

7.1.1. Setting the strategy for decommissioning

A set of strategic decisions needs to be taken by the top-level management of an organisation in order to prepare for the decommissioning of a nuclear facility, including:

- a nuclear material and/or spent fuel management strategy;
- a materials and waste management strategy;
- a remediation/site clean-up strategy;
- a dismantling strategy;
- a facility modification strategy;
- a technological strategy;
- a corporate strategy;
- an authorisation process.

These strategic decisions are influenced and constrained by several factors, namely:

- the funding situation;
- the policy and regulatory framework;
- the facility design and status;
- the available routes for the transport of radioactive waste;
- the available good practices and experience;
- stakeholder perceptions.

It is recommended therefore that detailed strategy making begin at least five years before the anticipated date of final shutdown. Installing a project organisation initiates and facilitates the change from a process-driven organisation found in nuclear facilities during operation to a project organisation for decommissioning. National and international experiences may help to prepare the strategic decisions which, once taken, need to be reviewed regularly and refined/changed as necessary.

7.1.2. Preparatory activities

In the last years of operation, and early after the cessation of operation, preparatory activities should be planned and initiated in order to reduce the hazards associated with dismantling activities. In addition, conducting preparatory activities as much as possible immediately following shutdown reduces the fixed costs and thus bears the potential of saving resources for the overall decommissioning project. Typical preparatory activities are:

- asset management;
- fissile material and spent fuel removal;
- shutdown of redundant systems;
- characterisation;
- material and waste management;
- decontamination activities.

It is recommended in particular that a holistic analysis of radiological and non-radiological hazards and risks be carried out. Preparatory activities should also focus on preventing surprises in D&D while at the same time preparing for them.

7.1.3. Authorisation for decommissioning

During the transition from operation to decommissioning, both the operator and the regulator through their supervision and inspection programme have the responsibility of ensuring that the facility is maintained in a safe condition and that adequate provisions to protect the health and safety of the public and the environment are in place.

To ensure the safe transition to decommissioning, the following key aspects should be considered:

- ensuring an early engagement of the operator with all regulatory authorities;
- setting clear regulatory expectations and defining the approval process prior to transitioning to decommissioning;
- clarifying the roles of all regulatory authorities involved in authorisation of decommissioning, and harmonising regulatory requirements and criteria between them;
- initiating an early engagement of all stakeholders;
- adjusting the regulatory approach to changing risk profiles during transition from operation to decommissioning and remaining flexible to adequately address this change.

7.1.4. Stakeholder engagement

Early and effective stakeholder engagement and informing of other interested parties is mandatory to build trust within the community and establish early confidence in the decommissioning project.

A clear definition of the intended interim states and end states of the decommissioning project is the basis for communicating with stakeholders, as well as for making the strategic decisions to prepare for decommissioning of the facility.

A stakeholder information plan should be established, which includes a strategy for the identification of stakeholders and a stakeholder management plan based on a clear communications strategy. The stakeholder information plan should foresee public information programmes using different media, like newspapers, brochures, online publications, etc.

Nevertheless, it is also important to clearly explain that stakeholder engagement is limited and that the licensee, who bears responsibility for conducting a decommissioning project according to the regulatory requirements, has the right to take decisions in its entrepreneurial responsibility (i.e. no representative participation without accountability).

7.1.5. *Organisation transition*

The purpose of organisation transition is to ensure that an effective and competent organisation is in place to deliver the decommissioning mission. The organisation's purpose should fit the decommissioning strategy. Several models have been developed in NEA member countries. The organisation that will conduct D&D is typically either the owner/licensee (self-performing the work) or a qualified contractor (sometimes referred to as a decommissioning operations contractor). However, the operator should always be part of the transition.

The preparation for organisation transition should begin well before the facility has shut down in order to allow optimum preparation of the facility for its subsequent decommissioning. Full advantage should be taken of the operating personnel, with their extensive knowledge of the facility: operating history, incidents, familiarity with the premises and the various equipment items, such that knowledge can be transferred to the decommissioning organisation. Maintaining previous operating staff will require that new skills and behaviours be developed. Training activities should be tailored to the specific competencies necessary for decommissioning activities.

The intended decommissioning organisation should have appropriate management systems in place. These include work management processes for the delivery of decommissioning (as opposed to the delivery of operations). The transition in this context is intended to deliver the required skills to decommissioning organisation in a managed and structured manner. Some organisations may decide to document the management system requirements for decommissioning through a specific quality assurance plan. This plan should be integrated into the overall management system of the organisation.

The management system's documentation should be reviewed and adapted to the requirements established by the national regulators for the decommissioning stage. All elements of the management system are important during transition. The delineation between decommissioning and operating governance should be ensured, for example, and existing documents should be revised as necessary. For instance, changes to operational documentation may be required, such as work control arrangements, equipment procedures and documentation updates applicable to new tasks, particularly as the shift occurs during the transition from operation to decommissioning, or from requirements on the reliability and availability of safety equipment to requirements on the reliability and availability of safety measures. The organisation, including contractors, could also develop sequencing risk process/tools oriented to waste generation reduction.

7.2. Areas for further work

This report's intention is to provide a comprehensive overview of considerations to be taken into account, decisions to be made and activities to be carried out, as well as the interrelations between key issues so as to prepare and plan for decommissioning of a nuclear facility based on experience and good practice in NEA member countries.

Within their activities and observations, the task group has identified several areas in the context of the transition of a facility from operation to decommissioning that would merit further attention and where the international community would benefit from further study via international experience sharing. Among the topics are:

- knowledge management: keep, transfer and maintain;
- training and qualifications;
- communications;
- human performance and demonstration of continuous improvement;
- integrated management and organisational change from the stakeholders' perspective;
- safety culture;
- programme and project management;
- supply chain management and the development of contracting models.

Chapter 8. Glossary

Within the context of the report the following terms are used in the described context:

Authorisation The granting by a regulatory body or other governmental body of written permission for a licensee to perform specified activities. Depending on the regulatory framework this may take the form of a licence, permit or approval.

End state A predetermined criterion defining the point at which a specific task or process is to be considered completed. Used in relation to decommissioning activities as the final state of decommissioning.

Facility A nuclear facility, where radioactive material is produced, processed, used, handled or stored on such a scale that consideration of protection and safety is required.

Licensee The **licensee** is the operating licence holder (or also referred to as ***operator***), who may also be the ***owner*** of the nuclear installation (NEA/RWM(2015)9)

Site A licensed or regulated location that includes one or more facilities designated for the use of radioactive materials.

Stakeholder Any actor – institution, group or individual – with an interest or with a role to play in the process (Webster, 2000), "Deliberations of Working Group 3 – Stakeholders and the Public: Who are they", in *Stakeholder Confidence and Radioactive Waste Disposal*, pp. 117-119, www.oecd-nea.org/rwm/reports/2000/nea2829.pdf (NEA, 2004).

Annex A1. Canada – Case study: Whiteshell Laboratories decommissioning management system documentation

Introduction

The decommissioning of Canadian Nuclear Laboratories Limited (CNL) Whiteshell Laboratories is currently described by the licence issued by the Canadian Nuclear Safety Commissioning that expires 31 December 2018. The laboratories are located in Pinawa, Province of Manitoba, Canada.

The Whiteshell Laboratories site was established by Atomic Energy of Canada Limited (now Canadian Nuclear Laboratories Limited) to carry out research and development activities for higher temperature versions of the CANDU reactor. Over time other research programmes were added. The organically cooled reactor WR-1 began operation in 1965 but the programme was discontinued in the early 1970s in favour of the heavy water cooled reactor CANDU system. The reactor was operated until 1985 in support of the other research programmes. They included the Nuclear Fuel Management Program, SLOWPOKE Demonstration Reactor Project and various accelerator activities. Atomic Energy of Canada Limited (AECL) took the decision to discontinue research programmes and operations at Whiteshell Laboratories and received the federal government acceptance in 1998 to close the site.

Whiteshell Laboratories's decommissioning licence was first issued in 2003. Since then there has been a gradual progression in the number of decommissioning activities being performed. During the transition phase to decommissioning AECL prepared the decommissioning quality assurance documentation and technical documentation, such as detailed decommissioning plans.

The original decommissioning plan estimated decommissioning to be completed by 2062. In 2008, AECL provided an accelerated schedule to 2037 from 2062, primarily related to cancelling the extended storage with surveillance state for the WR-1 reactor.

AECL's Nuclear Laboratories (which are responsible for implementing decommissioning activities) were restructured to implement a government-owned, contractor-operated (GoCo) model, similar to that being used in the United States and United Kingdom. As part of this restructuring, AECL's employees and operations were reorganised into CNL. In 2014, CNL became the licence holder due to the government moving to a government-owned, contractor-operated model. CNL now operates the facilities while AECL retains ownership of the assets and liabilities.

CNL is now proposing to further accelerate Whiteshell's decommissioning to 2025. It should be noted that institutional controls are expected for at least 200 years past site closure.

The decommissioning programme is unique since it addresses the entire research site, nuclear and non-nuclear. The site facilities were placed in a safe shutdown state; plans were initiated to place the facilities in a secure monitoring and surveillance state.

Licence and Licence Condition Handbook regarding the management system

The Canadian Nuclear Safety Commission's (CNSC) Regulatory Framework consists of laws passed by Parliament that govern the regulation of Canada's nuclear industry, and regulations, licences and documents that the CNSC uses to regulate the industry. Canadian Nuclear Safety Commissioning requires that persons or organisations subject to the Nuclear and Safety Act and the associated regulations are directly responsible for managing the decommissioning activities and implement the measures to protect the health and safety of persons and the environment. Prior to any nuclear activity occurring, a licence for decommissioning facilities must be issued by the CNSC. The licensee needs to demonstrate that it has fulfilled the requirements under the Nuclear Safety and Control Act and the associated regulations.

For major nuclear facilities, such as decommissioning facilities, in accordance with Class I Nuclear Facilities Regulations, an application for a licence shall contain a quality assurance programme for the activity to be licensed. If a licence is issued, the licence will require that "The licensee shall implement and maintain a management system". The Licence Condition Handbook associated to the licence provides the details and specifies the reference standards as the compliance verification criteria.

As per licence requirements, CNL will conduct the decommissioning activities in accordance with the submitted detailed decommissioning plans. The licence requires the licensee to (among other items):

- Implement and maintain decommissioning polices, programmes and procedures.
- Not deviate from the design operating conditions, purposes, methods, procedures or limits described in the safety analysis reports and/or operational limits and conditions documents that would result in an impact on health, safety or environment that is different in nature or greater in magnitude or probability than that described in those documents without prior approval of the commission or a person authorised by the commission.
- Implement and maintain a public information and disclosure programme.
- Implement and report on the progress of the Environmental Assessment Follow-up programme.

The Licence Condition Handbook contains, compliance verification criteria, information on delegation of authority to CNSC staff, references to licensee's documentation, references to standards and CNSC regulatory documents and commitments made by the licensee to ensure compliance with regulatory requirements.

In addition to describing the licence conditions and their compliance verification criteria, recommendation and guidance, the Canadian Nuclear Safety Commission's Licence Condition Handbook is organised according to the Safety and Control Area (SCA) framework. A SCA is a technical topic used by the CNSC to assess, review, verify and report on regulatory requirements and performance across all regulated facilities and activities. The SCAs listed in the Licence Condition Handbook for Whiteshell cover:

- management system;
- human performance management;
- operating performance;
- safety analysis;
- physical design;
- fitness for service;

- radiation protection;
- conventional health and safety;
- environmental protection;
- emergency management and fire protection;
- waste management;
- security;
- safeguards and non-proliferation;
- packaging and transport.

CNSC amended its regulatory framework in 2009 to evolve from having quality assurance requirements for the activity licensed to a broader set of management system requirements. Today, the CNSC requirement refers to a Canadian Standard Association nuclear standard N286 for management systems, developed and accepted by a cross section of Canadian industry representatives including CNSC staff.

Safe and reliable decommissioning requires a commitment and adherence to a set of management system principles and, consistent with those principles, the establishment and implementation of a planned and systematic patter of actions that achieve the expected results. An adequately established and implemented management system by a licensee provides CNSC staff confidence and evidence that the legal bases under which the CNSC made its decisions and had issued a licence remain valid.

The Management System SCA Covers the framework that establishes the processes and programmes required to ensure an organisation achieves its safety objectives, continuously monitors its performance against these objectives, and fosters a healthy safety culture. The specific areas for management system are:

- organisation;
- performance assessment, improvement and management review;
- operating experience (OPEX);
- change management;
- safety culture;
- configuration management;
- records management;
- management of contractors;
- business continuity.

The requirements to implement and maintain a training system are under SCA Human Performance Management. The licence also states that the licensee shall ensure that every contractor working at the facility complies with the licence and the compliance criteria are described by the Licence Condition Handbook.

CNSC staff verify the licence condition pertinent to the management system through a review of information as described in Licence Condition Handbook Compliance Verification Framework (e.g. inspections, technical assessments, event reviews), in association with Licensing Basis documents and in accordance with CSA N286.6-98 Decommissioning Quality Assurance of Nuclear Power Plants. The Licence Condition Handbook lists Whiteshell Laboratories Decommissioning QA Plan WLD-01913-QAP-001 and CNL Management Manual CW-5141000-MAN-001.

CNSC requirements regarding the management system for Whiteshell Laboratories decommissioning

CSA N286.6 Decommissioning Quality Assurance for Nuclear Power Plants specifies requirements applicable to the decommissioning phase of the nuclear plant life cycle. Clause 3 of this standard contains the generic requirements for managing the decommissioning of a nuclear power plant. These generic requirements are derived from the requirements of CSA Standard CAN/CSA-N286.0. Clauses 4, 5 and 6 which address the performance of specific work activities that are necessary during the decommissioning and that complement the requirements of Clause 3.

Each second-tier standard, such as CSA N286.6, embodies the principles set forth in the first-tier CSA N286.0 Overall Quality Assurance Program Requirements for Nuclear Power Plants. Each one includes specific programme requirements, limits of responsibility, authority, and application of criteria as they apply to the specific needs of each of the constituent phases of a nuclear power plant life cycle. There are the following second-tier standards that also are linked to the decommissioning standard:

- CSA N286.1 Procurement.
- CSA N286.2 Design.
- CSA N286.3 Construction.
- CSA N286.4 Commissioning.
- CSA N286.5 Operations. CSA Standard N286.5 has specific applicability during the decommissioning phase, because it is often difficult to distinguish a decommissioning activity from an operations activity. Depending on the stage of decommissioning, many activities described in CSA Standard N286.5 must be performed.

Clause 3 of N286.6 defines the requirements for the following generic activities such as programme definition (e.g. issuing a quality manual and identification of the participants), personnel capability, accountability, organisation and responsibilities, personnel capability, Use of experience, control of items processes and practices, verification, non-conformance and corrective action, change control, record and programme assessments (self-assessments and independent assessments).

Clause 4 of N286.6 defines:

- decommissioning authority;
- decommissioning documents (conceptual decommissioning plans, detailed decommissioning plans, hazards assessment, waste assessment, end-state documentation, decommissioning procedures);
- work control (procedure adherence, changes to inadequate procedures, inadequate emergency procedures, procedure implementation, work authorisation);
- materiel control: identification of systems, structures, and components;
- turnovers (system turnover to decommissioning, system turnover from decommissioning);
- status of systems, structures, and components;
- decommissioning surveillance;
- communication;
- radiological and non-radiological hazardous material control;

- contamination control;
- hazardous waste management;
- effluent control;
- worker safety;
- housekeeping;
- security.

Clause 5 addresses the link with the other N286 series standards.

Clause 6 describes:

- emergency classification;
- emergency response organisation;
- emergency plan;
- emergency facilities, equipment, and resources;
- personal protection;
- public information programme;
- evaluation of emergency program effectiveness.

N286-05 Management System Requirements for Nuclear Power Plants replaced CSA N286.0 Overall Quality Assurance Program Requirements for Nuclear Power Plants and sub-tier CSA Standards N286.1 through N286.6. The standards applies to all life cycles of a nuclear power plant and their overlap, eliminate duplication and inconsistencies among sub-tier standards, focusing on the management role in controlling and managing work processes.

In June of 2012, the Canadian Standards Association published the standard CSA N286-12 Management system requirements for nuclear facilities. The standard also applies to all the life cycle activities as in the previous versions but is now applicable beyond the power reactors to other licensed facilities. It is aligned with the principles of IAEA guidance and integrates the requirements from other management system standards such as quality, health and safety, environment, economics and security. The CSA N286 standard represents the industry current best practice for the principles fundamental to management processes and features important to the overall objective of safety. CSA N286-12 is becoming the licence condition standard for decommissioning.

N286-12 refers to the management system as: "The management system brings together in a planned and integrated manner the processes necessary to satisfy the requirements that must be met to achieve business success and sustainability".

The CSA group published a commentary document (N286.0.1-14) to the standard N286-12 in July of 2014. The commentary document covers some of the generic requirements and provides background information helpful for the implementation of a management system in line with the intent of the standard.

CNL (AECL) quality assurance documentation

The Whiteshell Laboratories Decommissioning Quality Assurance Plan (DQAP) was written following the guidelines of the company wide Quality Assurance Manual CW-5141000-MAN-001 and describes the programme applied to decommissioning activities at Whiteshell Laboratories. The programme applies to all facilities listed in the licence. The Decommissioning Quality Assurance Plan is supported by the procedures and operation instructions. Corporate wide procedures provide the overall directives while local procedures provide specific requirements and details. DQAP provides a cross reference between programme documentation and the CSA standard. This approach is a general practice used in the nuclear industry in Canada.

The document was submitted as part of the licence application. CNSC staff performed a technical review of the document and its referenced documentation and accepted the plan. The plan met CSA N286.6 requirements.

Whiteshell Laboratories has extensive and complex documentation for decommissioning activities and for the transition to decommissioning. The adherence to the requirements in those procedures is required by CNL senior management.

The Decommissioning Quality Assurance Plan presents and references the applicable documentation. DQAP contains the following sections:

1. organisation, authority, and responsibilities (organisational structure and functional responsibilities);
2. personnel capability;
3. accountability;
4. communication;
5. use of experience;
6. work planning and control;
7. control of items, processes and practices;
8. verification;
9. non-conformance;
10. corrective action;
11. change control;
12. document control;
13. records;
14. programme assessment (self-assessment and independent assessments);
15. requirements for decommissioning;
16. links with other quality assurance standards such as procurement, design etc.

Section "Requirements for Decommissioning" describes the specific activities and references all the documents. The section contains the following subsections:

1. decommissioning authority;
2. decommissioning documents (preliminary decommissioning plan, detailed decommissioning plans, work plans, hazard assessments, waste assessment, environmental assessment, end of state documentation, decommissioning procedures);
3. work control (procedure adherence, changes to inadequate procedures (stop work when procedure cannot be followed), inadequate emergency procedures (staff perform a safe back out and put the facility in safe statement when emergency procedure is inadequate), procedure implementation, and work authorisation);
4. material control;
5. turnovers;
6. status of systems, structures and components;
7. decommissioning surveillance;
8. communication;
9. radiological and non-radiological hazardous material control;

10. contamination control;
11. hazardous waste management;
12. effluent control;
13. worker safety;
14. housekeeping;
15. security.

The following examples present the content of some subsections of the DQAP:

- "Hazardous waste management" specifies among others that waste shall be segregated into radioactive and non-radioactive categories and waste shall be minimised thorough good housekeeping, appropriate practice and decontamination. CNL has generic documentation regarding the management of radioactive and non-radioactive wastes, packaging and low waste storage facility.
- The "decommissioning surveillance" section states that facility staff shall inspect daily any permanent shutdown nuclear facility or part of permanent shutdown nuclear facility to ensure that the shutdown state is maintained. Staff shall also perform routine housekeeping inspections in each facility. For facilities in "storage with surveillance" phases of the decommissioning, Storage with Surveillance Plans shall be prepared including details of facility specific inspection programmes specifying the frequency and responsibilities for physical inspections, equipment testing and monitoring of operating systems. Facilities for which Storage with Surveillance Plans have not been approved shall be inspected daily.
- "Work authorisation" states that prior to execution all decommissioning work shall be reviewed and authorised. The specific procedure provides a mechanism for verification by the Facility Manager, Subject Matter experts of the compliance, safety, engineering and operations disciplines that all requirements and supporting documentation have been identified. The decommissioning work performed by non-CNL personnel shall be assessed, controlled and authorised according to a specific documentation approved by CNL. Decommissioning will be performed as per Work Permit System that will be used by all, including the contractors.

CNSC compliance activities/lesson learnt

To ensure that licensee is complying with the conditions set in the licence CNSC staff is performing different type of compliance activities:

- audit (type I inspection);
- type II inspection base line compliance activities;
- review of annual compliance reports;
- review of reportable events pursuant to general nuclear safety and control regulations;
- review of non-reportable events submitted to CNSC;
- reactive inspections;
- review of changes to the documentation.

CNSC staff conducted an audit in 2008 to verify the Decommissioning Quality Assurance Program work in progress and activities implemented as per Decommissioning Quality Assurance Plan WLD-01913-QAP-001. The inspection assessed the records associated with decommissioning activities. The audit criteria were the licence, CSA N286.6 Decommissioning Quality Assurance for Nuclear Power Plants and

WLD-01913-QAP-001 (including the procedures) requirements. The audit inspected work activities in progress for different facilities and different decommissioning plans. It should be noted that this audit was performed when many of the decommissioning activities were at the initial stage or in planning stage since CNL is implementing a phased approach to decommissioning and is conducting physical decommissioning activities in discrete work packages. For the on-site inspection activities, the CNSC inspection team used a combination of document sample reviews and interviewed selected personnel to make observations.

Based on a no-surprise approach, the observations, which could result in findings, were then communicated to the Whiteshell Laboratories' single point of contact and CNL staff at daily morning briefings. The meetings provided the Whiteshell Laboratories staff with an opportunity to present clarification regarding the observations made.

The audit found some non-conformances with the audit criteria:

- Lack of a list with all records to be delivered to Records Office, project record kept by different groups and engineering files were not properly controlled. The status of records kept by different groups was not "indeterminate".
- The documents used for specifying and controlling the decommissioning activities did not define all steps necessary for accomplishing the work objectives safely. For example, the removal of manipulators and collar from a Cell required rigging and special contamination methods but the steps were not described by the work plan.
- The handling and storage of hazardous solid and liquid waste was not controlled to ensure safety. For example the temporary room for the storage of chemical materials was unsafely kept, with a fire potential.
- Boundaries were not clearly identified in the field for systems/areas turned over to decommissioning.
- Safety-related items and services were obtained from some vendors without a quality programme to assure the necessary quality and required performance.

CNL issued a corrective action plan to address CNSC enforcement actions. The corrective action plan contained the complete dates including checking for effectiveness of the corrective actions issued. The plan was reviewed by CNSC staff and accepted. CNSC staff performed a follow-up inspection to verify the implementation of the corrective actions.

In 2010 CNSC staff presented to the commission the information about the corrective action plan to improve the quality assurance implementation at Whiteshell Laboratories and about the status of the corrective actions for the enforcement actions from the CNSC staff audit performed in 2008. During the hearing, CNL provided information regarding the progress it has made especially on record control and job scope and safety analysis. The commission was satisfied with the progress made. All the CNSC enforcements actions were closed in 2011 after the review of their effectiveness.

In addition, during regular type II inspections performed yearly after 2011 by CNSC staff the elements of management system were also reviewed. CNSC staff observed the adherence to the quality assurance requirements stated in the WLD-01913-QAP-001. The management system implementation was rated as "satisfactory" by CNSC staff.

The status of the facility was changed from a research facility, which followed a set of operational quality assurance requirements, to a facility in decommissioning stage adhering to the requirements of CSA N286.6. The decommissioning requirements set in N286.6 were new for the staff; some staff was requalified to perform those activities. The early presence of CNSC staff helped for a more effective transition to decommissioning activities and provided valuable feedback to ensure compliance to the requirements.

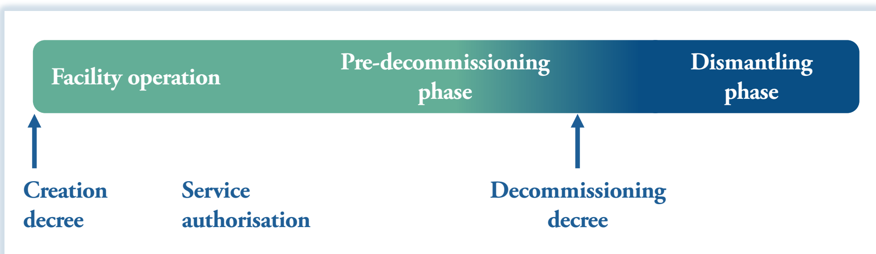
A.2. France – Case study 1: CEA decommissioning organisation adapted to Grenoble Nuclear Centre Nuclear Decommissioning Organisation

Introduction

The operations performed between the closure of the facility and the issue of the final shutdown and decommissioning authorisation ("pre-decommissioning" phase, see Figure A.2.1), must comply with the provisions of the facility's creation authorisation decree and its operating safety requirements.

The final shutdown preparation phase must allow optimum preparation of the facility for its decommissioning, taking full advantage of the presence of the operating personnel, with their extensive knowledge of the facility: operating history, incidents, familiarity with the premises and the various equipment items, etc.

Figure A.2.1: Facility timeline



How such operations are conducted? Everything starts with the definition of the scenario and the means of intervention to be implemented by collecting initial data on the facility (plans, equipment …) and evaluating its radiological condition (radiation levels, contaminated premises …). This scenario is made according to the facility safety document, for a basic nuclear facility in shutdown phase, changing the status from "operation to dismantling". It specifies the desired end state, the analysis of new risks arising from the operations, the waste generated, gas release, dosimetry, etc.

Consequences: a new mapping of radiological hazards is made with the individual at the heart of the scenario to ensure its protection against contamination or irradiation during operations. In parallel, an administrative record on waste management is developed, assessing their environmental impact to ensure that they will be accepted by the National Agency for Radioactive Waste Management (Andra). From the chosen scenario, and once the permits issued by the competent French Nuclear Safety Authority (ASN), follows the entry into pre-decommissioning phase: defining the scope of operations, installation of a ventilation system to protect the working environment, implementation of radiation protection equipment

Finally, work began, first to evacuate materials, then clean-up operations, (eliminate radioactive equipment and parts of facilities). This work is done upstream of dismantling phase.

Pre-decommissioning phase should be limited to the performance of the following operations:

- recent operations relating to the operation of the installation (phasing out experiments in a research facility for example);
- ordering the installation;
- preparation of the decommissioning operations (development of local, site preparation, staff training, installation of necessary equipment for dismantling);
- characterisation of the installation (production of radiological maps, especially on the basis of intrusive sampling and/or destructive collection of relevant elements for the decommissioning);
- modification, adaptation or improvement of utility networks (electricity, fluids, ventilation, etc.);
- discharge hazardous or radioactive substances in the installation (radioactives, chemical, fluid, waste, etc.).

Limited operations irreversible dismantling of equipment for the evacuation of radioactive and hazardous substances can be made during the preparation phase to making the final judgement.

Exceptionally, smaller pilot projects can also be made during this phase as part of the preparation for decommissioning.

During the decommissioning phase, the operator may need to implement new facilities or equipment in its regulated nuclear installation (INB), especially to make treatment and conditioning of waste operations.

The construction of a new plant or new equipment that will be used for decommissioning operations can optionally be carried out before obtaining the decommissioning authorisation.

When construction of the equipment requires a building permit or when work is reportable or outline planning permission, construction can start, however, after obtaining the building permit and after the closure of the public inquiry the marketing authorisation application file for the final shutdown and dismantling. In all cases, permission to build does not prejudge the authorisation to operate the equipment, which is issued by the decree making authorisation for final shutdown and dismantling or, where applicable, authorisation or approval of the regulator.

Nuclear Energy Division

Under the authority of the General Directorate, the Nuclear Energy Division fixed the strategic orientation and missions of the nuclear division. It fixes the means necessary for achieving the objectives and controls the different programmes.

CEA’s strategy under the regulatory framework: nuclear laws 2006 TSN and waste:

- Immediate and total decommissioning when feasible. Technical and economical optimisation pursuit.
- End state: removal of all dangerous material (in particular radioactive ones). If impossible: decommissioning with constraints, with an impact always less than 300 µSv/yr.
- Solid and liquid waste: minimisation, optimisation of categorisation, on-site evacuation.

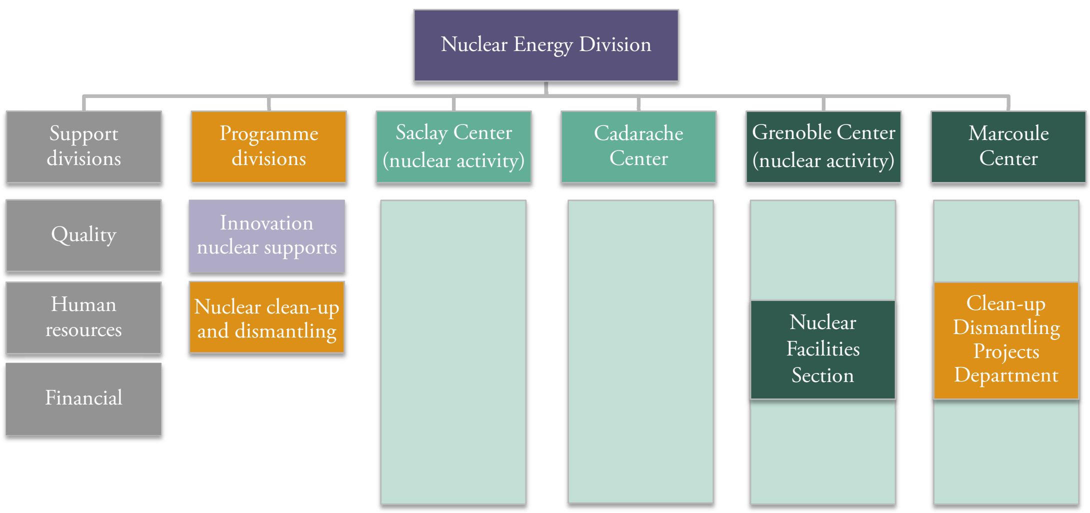
The main missions are:

- Take responsibility for the implementation of research programmes on future systems of production of nuclear power and, correspondingly, those relating to fuels aspects, nuclear safety, spent fuel processing and optimised nuclear waste management.
- Provide, upon request, support to industry and organisations for the current nuclear fleet t and fuel cycle facilities and develop in its field of activities, co-operation at national and international level.
- Ensure responsibility for waste management facilities and waste treatment of the entire CEA and the remediation and decommissioning of facilities (Nuclear CEA civil and the UP1 plant at Marcoule site).
- Maintenance of its nuclear facilities and installations at the level required by nuclear safety requirements and through careful management of resources available as well, in the same spirit, the management of its real estate trivialised.
- Contribute to the development of generic technologies in the program transversal advanced materials.

Two nuclear centres are under the direct responsibility of the Nuclear Energy Division: Cadarache and Marcoule (see Figure A.2.2).

For two others centres (Saclay and Grenoble) only the nuclear activity within the centres are under the Nuclear Energy Division responsibility, the management of the centre is under the responsibility of other Divisions.

Figure A.2.2: Organisational chart: CEA Nuclear Energy Division



Nuclear Clean-up and Dismantling Division (up to end 2016)

The Nuclear Energy Division has the responsibility firstly to carry out all of the decommissioning programmes of the CEA and on the other hand to ensure the management of waste, materials and spent fuel for all CEA civilian sites, including the management of transport and associated packaging.

The Nuclear Clean-up and Dismantling Division missions are organised in eight programmes:

- Marcoule decommissioning;
- Cadarache and Grenoble decommissioning;
- Saclay decommissioning;
- Waste, materials management;
- Nuclear support facilities;
- Transports and outlets;
- ITER decommissioning and tritiated waste;
- R&D valorisation and decommissioning.

Within the Nuclear Clean-up and Dismantling Division, each programme is assigned to a programme manager who is the strategic driver.

The strategic driver, sets the objectives and ensures the strategic management of the projects (performance, cost, time), the management rules, financial resources and staff budgeted.

Decommissioning Project Department

The department (depending from Marcoule Center) ensures the operational management of decommissioning projects and waste retrieval and packaging on behalf of the Strategic Pilot (Nuclear Clean-up and Dismantling Division). The department is particularly responsible for the consolidation and optimisation of load plans, resources and budgets required for current and future performance of its operations. It must also guarantee the standardisation of working methods and the capitalisation of experience in decommissioning projects.

In this framework, each project is assigned to a Project Manager, responsible for project management and reporting to the Nuclear Clean-up and Dismantling Division programme manager.

The project organisation is based on a matrix operation of “business” leaders are assigned on a project or set of projects as required, to bring the project manager technical support and methodological contribution:

- project management (risk analysis, planning, monitoring cost estimates);
- safety/decommissioning;
- waste/transport;
- technical studies, technical expertise (remote operation, characterisation, chemical engineering, ventilation);
- interfaces/facilities.

Organisation set-up for the decommissioning of Grenoble nuclear site

The PASSAGE project

Created in 1956, the CEA Grenoble is one of the civilian centres of the Commissariat à l’énergie atomique.

Since January 2001, the centre has been engaged in a remediation and dismantling plan of its nuclear facilities. The project, entitled PASSAGE, last 15 years. The final decommissioning was finalised in 2015.

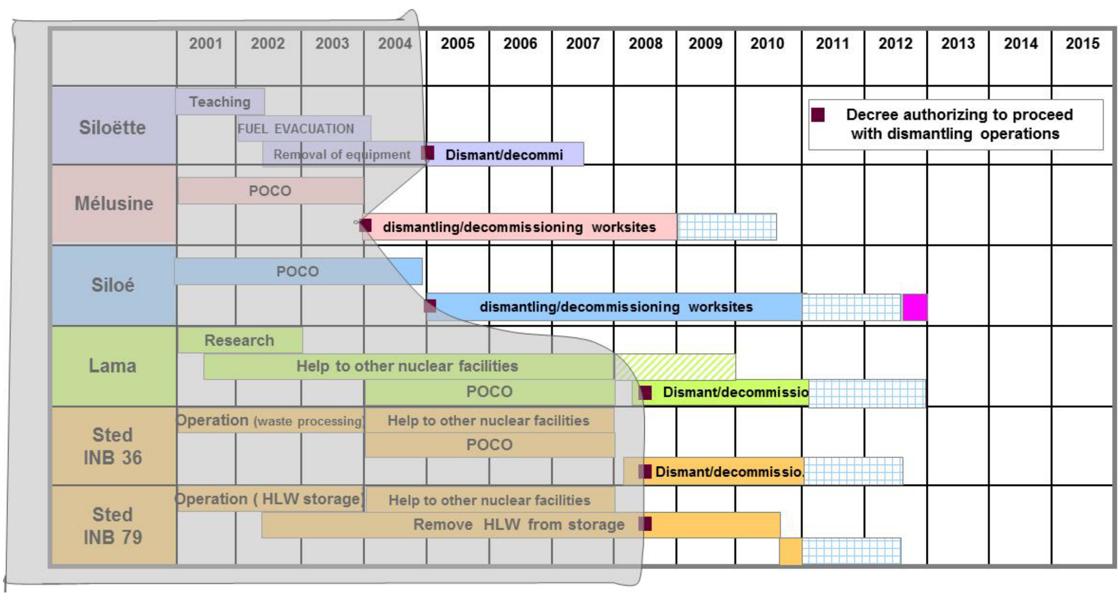
The centre includes six basic nuclear facilities:

- INB 19 (Melusine) reactor shut down since 1988;
- INB 20 (Siloé), reactor shut down since 1997;
- INB 21 (Siloette) reactor shut down since 2002;
- INB 61 (LAMA) laboratory analysis of radioactive materials;
- INB 36 (Sted), solid storage facility;
- INB 79 (Sted), decay storage facility.

The PASSAGE project (decommissioning of the six nuclear facilities) symbolises the evolution of the CEA Centre in Grenoble, from its nuclear origins to the recognised position it occupies today in the fields of microelectronics and micro and nanotechnologies. The objective of this project was to enable the reuse of decommissioned buildings and their integration into the new life of the centre.

A dedicated organisation has been set to control the project. A steering committee consisting of representatives of the main directions of CEA most involved, which meets twice a year to check the progress, decide on possible new directions and check the right the means used and objectives.

Figure A.2.3: Global overview of the PASSAGE project



Project organisation

The Nuclear Clean-up and Dismantling Division as project owner delegates its function to the Decommissioning Project Department represented by a project manager (DD&R project manager).

By delegation, the Director of the Grenoble Centre (Technology Research Division) is in charge of all activities on the site. The operator (facility manager) is responsible for safety and the safety of all operations in within the nuclear facilities and is under the responsibility of the Nuclear Energy Division

Units of the CEA of Cadarache or Marcoule centres provide technical support, expertise safety and security of the decommissioning operations and operating. In addition, an entity of the Grenoble Centre responsible for supervising the activities involved in nuclear safety and security (as control of 2nd level).

The denuclearisation of the CEA/Grenoble is designed globally:

- the facilities are all complementary;

Examples:

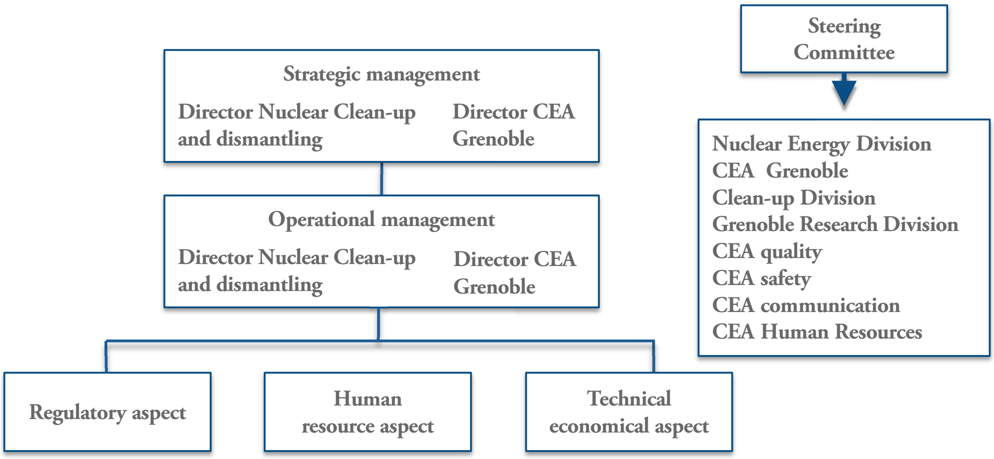
  - Siloé is used for cutting objects from Melusine reactor;
  - Lama is used for reconditioning of containers High Activity from STED facility.

- the hierarchical organisation is by profession (not facility):
  - optimisation of manpower;
  - rationalisation of operating modes between the different facilities.
- whenever possible, contracts are "cross" and multi-facilities:
  - assistance in project management;
  - support for operation;
  - decommissioning.

This organisation has been set for efficiency and exploitation of skills and resources with high level of delegation and project control. It has been adapted to the needs which mean the constant evolution of the project, based on macroscopic risk analysis.

The steering of the project is provided by the steering committee involving stakeholders from CEA Grenoble and management representatives of the CEA (see Figure A.2.4). It meets twice a year to check the progress, decide on eventual new directions and check the adequacy of the means used and goals.

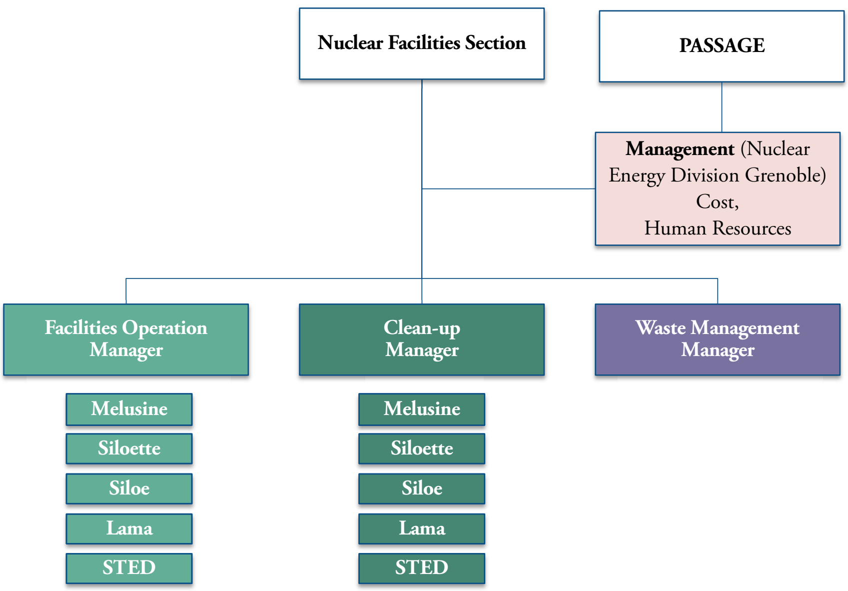
Figure A.2.4: CEA Grenoble project organisation



This type of organisation needs mutual respect and complementarity between actors of the project: (see Figure A.2.5 below):

- responsibilities and respective missions:
  - simplified, explicit, readable in the hierarchical structure;
  - described in the management plan (no need of interface procedure).
- management of decommissioning projects:
  - Chief Operating Officer (Deputy Leader facility) member of the project team;
  - Binomial Project Manager – Deputy Facility Manager;
- Steering PASSAGE:
  - head of facilities manager member of PASSAGE project team.

Figure A.2.5: Organisation of the PASSAGE project



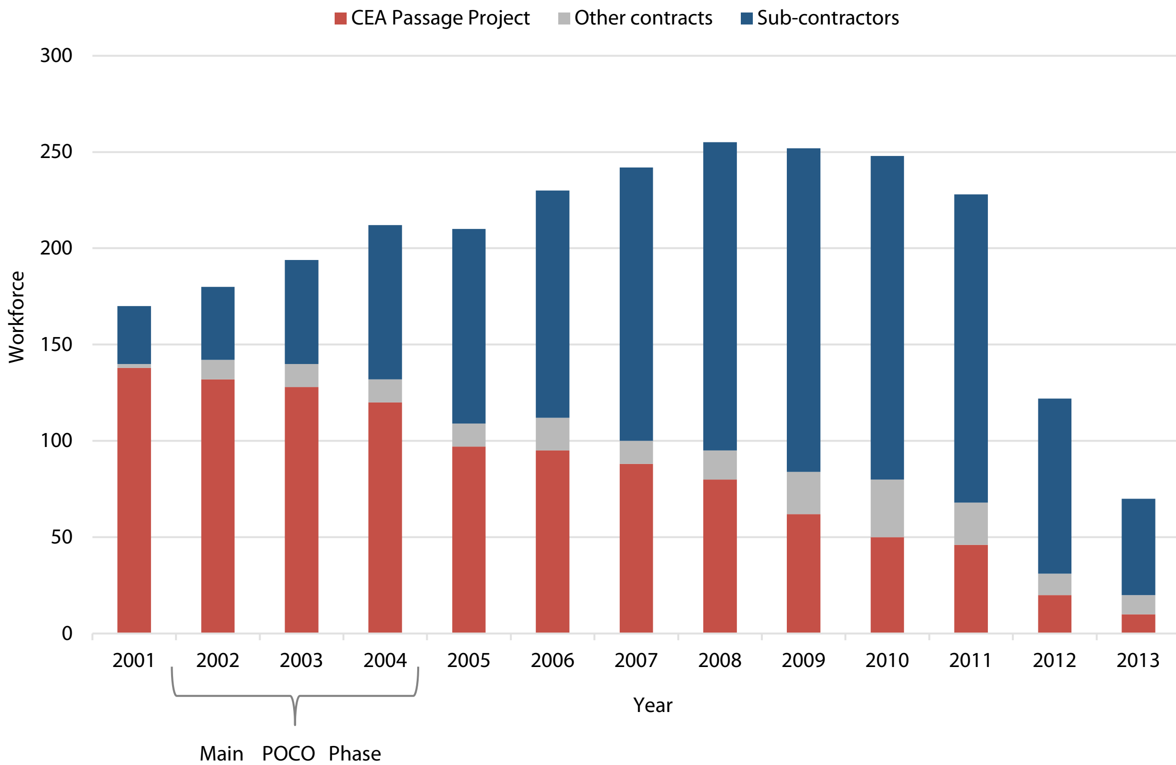
Human resources

Initially (during pre-commissioning activities see Figure A.2.6 below), the CEA relied on its own personal operating the facilities to control the security and the clean-up of experimental means. Gradually, companies specialised in dismantling took in charge all technical operations with CEA continuing to ensure the project steering and control of security.

At the same time, an internal conversion plan for employees was developed and implemented aiming at involving the workers in the project but also providing an outlook and perspective for the future for them. As such, discussions with the social partners were undertaken to ensure them a repositioning in a new sector of activity at the end of their planned involvement in the project.

Moreover, an important work of collecting the “feedback” accumulated by the employees of the project was done on a continuous basis, so that all CEA dismantling actors can benefit from it.

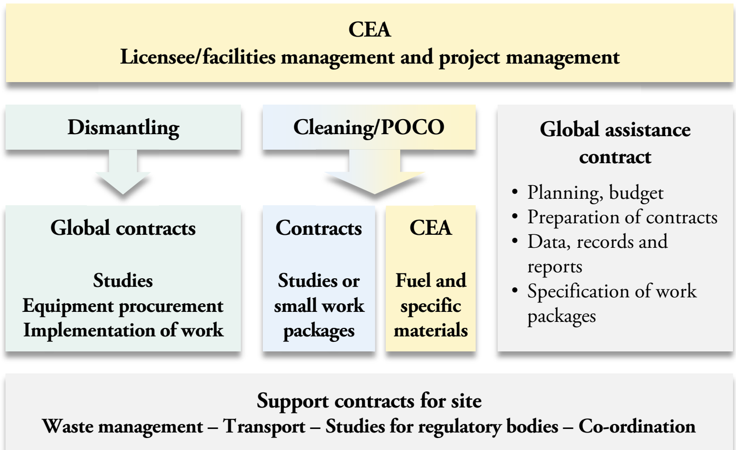
Figure A.2.6: CEA human resource planning



Subcontracting aspects

During pre-decommissioning activities, the contracts were mostly used for preliminary studies or small clean-up operations in the facilities. Global project management assistance (see Figure A.2.7) was already used, as well as support contracts for waste management, transport, co-ordination and safety. These contracts are turned later on into a global contract when the time for dismantling operations comes.

Figure A.2.7: CEA licensee/facilities management and project management



Annex A.3. France – Case study 2: EDF-FBR 1 240 MW

Background

Decommissioning strategy:

Immediate decommissioning.

Schedule:

30 years.

Actual status:

Vessel internal part (fuel supporting plate) dismantling phase will start in 2019:

- sodium has been drained from primary and secondary circuits;
- secondary circuits are dismantled (except secondary heat exchangers);
- main primary equipment has been dismantled from the vessel (heat exchangers and pumps).

Experience in transition from operations to decommissioning in other projects:

Nine reactors in dismantling phase.

Decommissioning preparatory activities

Summary

- The first decommissioning engineering activities studies started just a few months after the final shutdown (1998) with the aim to prepare the request for decommissioning decree and to undertake as soon as possible the transition period activities.
- Activities have been first concentrated on turbine hall dismantling, chimneys dismantling, removal of large steam pipes in order to give visible signs that decommissioning has started. The main transformer and the high voltage lines have been also dismantled at that time.
- Then some ancillaries systems were customised to suit dismantling needs:
  - commissioning of a new pumping station to suit lower needs: from 150 000 m^3/h to 1 500 m^3/h;
  - new demineralisation unit: from 5 000 m^3: H per day to 40 m^3/day;
  - site electrical supply: from 225 kV to 20 kV.

In parallel, conceptual and basic designs were developed to prepare the ground for the dismantling licence request file. Finally, the NOAH process was selected for sodium treatment. After a risks analysis it was concluded that two small sodium treatment units would be better than a larger one.

The waste route for soda (produced by NOAH process) was really innovative as the soda is concentrated in a cement matrix within 1 m^3 big bags.

- Safety diesel engines were sold and diesel building emptied from their equipment.
- No buildings were demolished during the decommissioning preparatory activity as the decommissioning funds were allocated in priority to the sodium risk reduction.

Regulatory framework (plant/site history "previous characterisation data")

Regulator/types of licences required

In operation from 1986 to 1998. The request for decommissioning licence was issued in April 2003. The decommissioning licence was granted on 21 March 2006 with an environmental target reducing drastically the releases to atmosphere in august 2017 linked to the end of the sodium treatment (sodium traps). This decree authorised the sodium treatment using different technologies (hydrolyse, carbonatation, etc.).

Licensing strategy used

A request for dismantling decree has been submitted to the regulatory body covering the complete dismantling phase. The dismantling decree contains some hold points for some specific milestones (for example the commissioning of the sodium treatment unit and the filing of the reactor vessel with water after sodium drainage and treatment).

Licensing documents for submittal to regulator (including support documents needed)

- description of the plant;
- environmental impact study;
- waste management plan;
- dismantling plan;
- safety analysis report;
- operating and surveillance rules.

Regulatory oversight during transition period

The regulatory body has inspected and continue to inspect regularly the site.

Public involvement/stakeholder engagements

See social economic section.

Decommissioning planning

Main strategies and approaches used

The strategy was first to show to the public that the dismantling phase was really engaged. Then the strategy for sodium disposal was set up.

Concerning waste treatment and storage, the policy was to keep existing buildings. So the turbine hall was used to house the sodium treatment facility, but some constraints against seismic risk were raised and lead to extensive reinforcement works.

Due to the need to monitor permanently the sodium risk using the relevant operating procedures, it has not been possible to have a cold and dark approach for systems shutdown. Systems were progressively decommissioned under specific and somehow complicated procedures.

Decommissioning scope, start and end point

It can be considered that the transition period lasted from final shutdown (1998) to decommissioning decree issuance (03/2006). During this transition period, non-nuclear equipment has been dismantled. The dismantling of the first nuclear components started just after the DEC decree issuance

Defueling and fuel logistics strategy

Fuel removal from the vessel started immediately after shutdown as it was authorised in the decree stating the plant final shutdown issued in 12/1998.

Waste management strategy

The waste management strategy for this site is part of a global strategy linked to a "non-release threshold" national approach. The waste classification is based on the waste zoning, it means that any equipment located in a nuclear zoning is considered as a nuclear waste. Then characterisation measures help to determine what is the appropriate waste route (such as ILW-MLW waste repository or very low-level waste [VLLW] repository).

The waste packaging is done on-site and then wastes are transported to existing intermediate-level waste and VLL waste national repositories.

The concrete blocks containing soda are temporary stored on-site.

Social/economic impact

Special funds were allocated from 1998 to 2005 for mitigating social aspects in order to ease the economic and social transition. The objectives were to assist people that had lost their jobs and support development projects involving private companies, associations and local communities

About 208 signed agreements were signed with companies and around 1 300 jobs were created and maintained).

The social/economic plan has been eased thanks to a very dynamic area located at 50 km from the plant.

Public acceptance: Implication of the plant owner and local economical actors in addition to a good communication about the technical solutions proposed by the plant owner have contributed to obtain a good public acceptance for the dismantling.

Business strategy and financial provisions

The breakdown of responsibilities and contract allotment was the following:

- nuclear safety and licensing responsibility: operating owner of the plant;
- project management: operating owner of the plant through its dedicated engineering unit;
- basic design responsibility: the initial designer for the core systems and the owner for the rest (through internal engineering unit);
- procurement management: owner with the support of internal procurement division;

- activities during "transition period":
  - post-operation clean-up, draining , operational wastes: former operating team;
  - progressive shutdown activities: mainly dedicated contract and support from former operating team;
  - fuel handling: former operating team with the support of specialised company;
  - turbine hall dismantling: dedicated contract;
  - construction of temporary waste storage areas: dedicated contract;
- decommissioning funds were available at the time of shutdown.

Decommissioning organisation and staffing

Corporate and decommissioning site organisations and interactions

The responsibility of the dismantling project remains within the operator/owner. In early 2000, a dedicated structure was created to co-ordinate, prepare and follow up all the dismantling activities for GEN 1 and fast breeder reactors.

Concerning the site staff:

- 1999: 650 owner staff + 450 subcontractors staff;
- 2006: 110 owner staff + 300 subcontractors staff;
- 2016: 85 owner staff + 3 500 subcontractors staff.

Planning, implementation and project management approach for optimisation

The planning and implementation is under the responsibility of the Project Manager. According to dismantling plan and project risk analysis, the project manager has proposed the following allotment.

Services contracts

Overall operating of safety systems needed for dismantling: owner through a dedicated team.

- ancillaries systems operations and maintenance: dedicated contract;
- radioprotection support: dedicated contract;
- logistic for waste management at site: dedicated contract.

At site work contracts

- turbine hall dismantling: "fixed-price" contract;
- dismantling of miscellaneous nuclear systems and equipment: several "fixed-price" contract;
- vessel and internal segmentation: dedicated contract including basic design withhold point before to engage detailed design.

Comments: due to the unique character of the plant, it has been found suitable in a risk mitigation approach to keep the know-how of the designer and to contract with him the basic and detailed design for the dismantling of the reactor vessel and major components and cold traps.

Experience and knowledge management methods

Some recruitment of young engineers at the beginning of the decommissioning project has been done to train them on sodium technology. This has been considered as a good practice to maintain the know-how until the end of sodium risk.

The design documentation kept at site was very helpful to build the dismantling scenario and to prepare the work on-site.

Preparation and training of decommissioning staff

Specific training courses were organised to train some former operators staff to decommissioning/dismantling projects specificities.

Projects conducted during transition period

Initial site characterisation

Circuits characterisation in view of preparing the acceptance files for final disposal.

System and building decontaminations

The plant was in good shape and no special action towards decontamination has been engaged for the time being on the civil works.

Draining and treating sodium can be considered as part of the decontamination process.

Asset management

Special attention is paid continuously to building maintenance through dedicated maintenance plan.

Disposition of operational waste

- nothing special to report;
- installation of a waste temporary storage area in the turbine hall.

Technology and technical requirements – preparations for dismantlement projects

- The key point for fast neutron reactors is the treatment of sodium. A dedicated team has been set just after the final shutdown to find a solution for sodium treatment. Among the few available technologies, the hydrolyse technology has been retained. The sodium treatment workshop was installed in the turbine hall after removal of all equipment in the turbine hall.
- Due to the high level of radiation in the vessel and unfriendly atmosphere in the reactor vessel (Argon gaz and sodium residues), specific laser remote tools have been developed to cut pipes inside the vessel.

Lessons learnt

Positive results

- Wide experience gained in sodium treatment through hydrolyse (5 900 m^3).
- Experience in remote laser cutting in unfriendly atmosphere.
- The dedicated funds for social and economic aspects efficiency have been proven.

- As the decommissioning activities and basic design started immediately after shutdown the access to a well-organised documentation is part of the success of this project.

Difficult challenges

- Need to maintain significant and motivated operating team until final removal and treatment of sodium.
- The management of the contract for progressive shutdown of systems is very heavy in terms of preparation of works due to a too detailed approach per systems. The opportunity to have a cold and dark strategy has to be considered.
- Operating staff reduction has been a real challenge as the final shutdown of the plant was not expected; therefore, there was no time for preparation.

Annex A.4. France – Case study 3: EDF-PWR 305 MW

Background

Project:

PWR 305 MW.

Decommissioning strategy:

Initially safe store approach then moving to immediate decommissioning in 2001.

Schedule:

30 years.

Actual status:

Vessel segmentation in progress.

Steam generator moved to VLL wastes repository after decontamination.

Experience in transition from operations to decommissioning in other projects:

Nine reactors in dismantling phase.

Decommissioning preparatory activities

Summary

- 1998 1999: shutdown activities, circuits draining, surveillance of the installation.
- 1999-2007: partial dismantling of the installation.
- 2007-2008: layout works (ventilation, waste management).
- 2008-2013: heavy dismantling activities.

Regulatory framework (plant/site history “previous characterisation data”)

Regulator/types of licences required

- In operation from 1967 to 1991, final shutdown in 1993.
- End of fuel removal: December 1995.
- Dismantling decree in 09/2007.

Licensing strategy used

Until early 2000, the strategy was safe store. This strategy changed in 2001 for a prompt dismantling. Then a request for dismantling decree has been submitted to the regulatory body covering the complete dismantling phase.

Licensing documents for submittal to regulator (including support documents needed)

- description of the plant;
- environmental impact study;
- waste management plan;
- dismantling plan;
- safety analysis report

Regulatory oversight during transition period

The regulatory body has inspected regularly the site.

Public involvement/stakeholder engagements:

No special concerns as there are two other NPP in operation on the site.

Decommissioning planning

Main strategies and approaches used

Initially safe store approach with long-term surveillance.

Defueling and fuel logistics strategy

Fuel removal from the vessel immediately after shutdown.

Waste management strategy

Waste packaging on-site. Temporary storage of waste on-site as a buffer before transportation to existing M-L waste and VLL waste national repositories.

Social/economic impact

Very limited impact as there are two other NPP in operation on this site that were in capacity to absorb staff coming from the shutdown plant.

Business strategy and financial provisions

N/A (decommissioning funds available at the time of shutdown).

Decommissioning organisation and staffing

Corporate and decommissioning site organisations and interactions

The responsibility of the dismantling project remains with the operator/owner. A dedicated structure was created, in early 2000, to co-ordinate, prepare and follow up all of the dismantling activities for GEN 1 reactors.

Planning, implementation and project management approach for optimisation

The planning and implementation is under the responsibility of the Project Manager. According to dismantling plan and project risk analysis, the project manager has proposed the following allotment.

Allotment for dismantling period

Services contracts

- safety systems needed for dismantling overall operating: owner through a dedicated team supported by the neighbouring NPP;
- ancilliaries systems operations and maintenance: owner through dedicated team supported by services contracts and by the neighbouring NPP;
- radioprotection support: part owner through dedicated team supported by services contracts and by the neighbouring NPP;
- logistic for waste management at site: owner through dedicated team supported by services contracts and by the neighbouring NPP

At site work contracts

- dismantling of miscellaneous nuclear systems and equipment: dedicated contract;
- vessel and internal segmentation: dedicated contract;
- demolition of conventional buildings (turbine hall): dedicated contract.

Experience and knowledge management methods

Experienced operators were no more available when it was decided to cease the safe store approach.

Preparation and training of decommissioning staff

Specific training courses were organised.

Projects conducted during transition period

Initial site characterisation

Turbine hall demolishing in order to have place for construction of a waste temporary storage area. Circuits characterisation in view of preparing the acceptance files for final disposal.

System and building decontaminations

NSSS equipment decontamination has been done just before SG dismantling with the view of transportation of the complete SG to VLLW repository (not during the transition period).

Asset management

Special attention is paid to building maintenance through dedicated maintenance plan

Disposition of operational waste

Nothing special to report.

Technology and technical requirements – preparations for dismantlement projects

Due to initial safe store approach, no decontamination after shutdown was undertaken. However, decontamination has been implemented for SG just before their dismantling in order to send them to VLL waste repository.

Lessons learnt

Positive results

Decontamination of SG leads to consider them as VLLW. Logistic support from the running plants on-site is beneficial.

Difficult challenges

Insufficient documentation and preservation of special tools during transition period have led to some costs overrun during dismantling period.

Annex A.5. Sweden – Case study: Decommissioning in Vattenfall

Introduction

Ringhals Nuclear Power Plants (NPP) consists of four reactors; one boiling water reactor (BWR) (Ringhals 1) and three PWR (Ringhals 2-4). Ringhals NPP company (Ringhals AB) is co-owned by Vattenfall AB (70.4%) and Uniper (29.6%) but due to a historic government approved settlement, Vattenfall has the full financial responsibility for the decommissioning.

In 2015, due to economic reasons a decision was taken to shut down permanently in 2020 and 2019 the two oldest reactors Ringhals 1 and Ringhals 2. The two newer reactors Ringhals 3 and 4 will continue operation until the first half of 2040.

Up to this point, the decommissioning planning of Vattenfall Group and its majority owned NPPs has been carried out separately, with minor co-ordination between plants. However, in conjunction with the decision to shut down of Ringhals 1 and 2, Vattenfall decided to create a decommissioning organisation (Business Unit Nuclear Decommissioning) with the sole task of co-ordinating all of the Vattenfall decommissioning programmes. The current plan for the decommissioning in Ringhals is for Vattenfall to apply for the nuclear licence for Ringhals 1 and 2 for a defueled plant status. This is however pending a recommendation from Swedish Safety Radiation Authority (SSM) after an extensive review and finally pending an approval from the Swedish government. If the nuclear licence for Ringhals 1 and 2 for any reason cannot be obtained by Vattenfall as described above, the current intention is then to achieve the same organisational separation between decommissioning of Ringhals 1 and 2 and the operation of Ringhals 3 and 4, but within the Ringhals AB organisation.

The following two sections describe the current plans for the final shutdown, defueling and decommissioning in Ringhals. Finally, a summary of arguments on the main approach taken for decommissioning set-up is provided.

Final shutdown and defueling in Ringhals

A project (STURE) was initiated as a consequence of the decision to shut down Ringhals 1 and 2 with the primary goal of completion of the final shutdown and the following defueling of Ringhals 1 and 2 and prepare for the coming decommissioning. The project STURE should also serve as the counterpart to specific decommissioning projects.

The project STURE has been organised in subprojects with the following main tasks:

Organisation

- Secure key staff and competence within the Ringhals 1 and 2 organisations to enable safe and secure operation until planned final shutdown and through the defueling period.
- Maintain an effective safety culture through the completion of defueling.
- Facilitate the organisational transition from four units to two units.

Technical arrangements

- Plan for and carry out defueling activities.
- Physically separate common support systems between Ringhals 1 and 2 and Ringhals 3 and 4 to enable decommissioning and continuous operation.
- Identify, assemble and, if necessary, develop plant documentation to support shutdown, carry out defueling activities and facilitate the licence transfer to the decommissioning company.
- Execute necessary pre-decommissioning activities on behalf of the decommissioning organisation before possible licence transfer (e.g. preparatory site work, carry out full system decontamination after shutdown etc.)
- Ensure that all legal conditions are met to close down Ringhals 1 and 2 and enable a transfer of the licence to the decommissioning organisation after defueling if so is decided.

Financial optimisation

- Financial management to maintain the competitiveness of Ringhals and to manage impacts on the Ringhals business plan due to closing down of Ringhals 1 and 2.
- Optimise management of the nuclear waste fund and manage financial arrangements involving the decommissioning company.
- Ensure optimal management of investments, fixed assets and inventory.

Decommissioning programme and organisation in Ringhals

All the decommissioning tasks in Ringhals are currently planned to be organised in a programme that will consist of both decommissioning projects and line activities. The organisation for all the decommissioning tasks will consists of two main parts: a line organisation and a programme and project organisation.

Decommissioning line organisation

The line organisation includes functions necessary for holding a licence for an NPP cleared of nuclear fuel, including an adapted management system with functions for safety management and operation management. The line organisation is also responsible for securing key competences for the organisation, developing their skills and managing experience feedback from the decommissioning projects, international experiences etc.

The line organisation develops the generic decommissioning concepts/models and defines the overall framework and requirements for the decommissioning projects, based on Vattenfall's and Ringhals' strategic direction, external requirements etc. The line organisation will follow up on the project's progress and provides support if necessary. Contacts with the safety authorities are co-ordinated by the safety manager. The documents submitted to the authorities are reviewed by the line organisation.

Decommissioning programme and project organisation

The programme and project organisation plans and executes all decommissioning activities and projects. Key competences necessary for the projects should be positioned within the programme and project organisation. Other competences needed in the specific projects are assigned full- or part time from the line organisation, the old plant operator, Vattenfall or from contractors. The overall strategy is to execute the decommissioning and dismantling activities to large extent with experienced contractors.

The programme and project organisation perform the general planning, licensing work, procurement and finally provide management and support to the contractors carrying out the decommissioning plan. The detailed planning is done side by side with qualified contractors.

In contacts with the authorities concerning planning and progress the program and project organisation is working in close co-operation with line organisation and the decommissioning safety manager.

Arguments for selected organisational approach

There are from a generic Vattenfall perspective many advantages of separating decommissioning organisation from NPP operation organisation preferably using an existing and specialised decommissioning organisation.

- The proposed set-up makes it easier for the organisations to maintain full focus on the core business. The operating organisation can focus on safe and secure operation and the decommissioning organisation on how to optimise decommissioning. In an organisation responsible for both actions, the decommissioning will always come in second place.
- International experience has shown that it is hard to carry out an effective decommissioning project in an organisational structure and with a management system that is adapted for power operation. A specific decommissioning organisation makes it possible to customise the organisational structure and management systems to support the decommissioning activities.
- A specialised decommissioning organisation makes it easier to focus on the safety aspects that are relevant for decommissioning which differ significantly from a plant in operation.
- When building a new organisation it is possible to employ competences needed for the decommissioning work instead of using the available staff in the operator's organisation, regardless of competence. A specialised decommissioning organisation also makes it easier to build expertise and gain the management experience in the long term.

Annex A.6. Switzerland – Case study: Muehleberg NPP, BWR 390 MWe

Background of the test case

Decommissioning strategy:

Prompt decommissioning

Schedule:

2020-2031

Actual status:

The board of the company came to the decision in Oct., 2013 to shut down the plant at the end of 2019.

Final decommissioning plan submitted to the granting authority (Federal Department of the Environment, Transport, Energy and Communications, DETEC) in December 2015. Applying for the decommissioning order coming into force at the end of 2019. Dismantling strategy is definite.

Expertise from several institutions for granting the order are expected at the end of 2017.

Experience in transition from operations to decommissioning in other projects:

Only some research reactors and conditioning facilities have been decommissioned respectively are in the decommissioning stage. All of them had a transition phase of some years without preparatory work for decommissioning.

This case (prompt decommissioning with fuel on-site) is a new approach.

Decommissioning preparatory activities

Summary

Planning of the project (licensing) has started six years before shutdown, and engineering four years before shutdown.

An extensive set of decommissioning preparatory activities within the force of the operation licence (during the last years of operation and the first months of the transition period) is getting underway:

- Radiological Characterisation will be continued and updated before and after shutdown.
- Conditioning of operational waste will continued in the operation period and finished in the second dismantling phase (phase after defueling).
- Backfitting of the spent fuel pool cooling systems.
- Transfer spent fuel from reactor vessel into the spent fuel pool during the first months after shutdown.

- Unloading (packaging and transfer to intermediate storage) spent fuel from the spent fuel pool as soon as reasonably possible.
- Decontamination of primary system is not preferred (low radiological level), but decontamination of some auxiliary systems and components are planned.
- Declassification, abandonment, discharge of systems and equipment, structures and modifications to existing systems will be conducted as soon as possible after shutdown.
- Removal of hazardous waste.
- Construction/renovation of auxiliary facilities (e. g. for waste treatment) and preparation of work areas to support dismantling and treatment activities will start promptly after shutdown

Regulatory framework (plant/site history "previous characterisation data")

Regulator/types of licences required

With the decision of the owner for prompt decommissioning an inter-institutional monitoring group for the preparation of decommissioning lawsuit was installed.

Members

- Swiss Federal Office of Energy (SFOE), authority for the lawsuit.
- Swiss Federal Nuclear Safety Inspectorate (ENSI).
- Federal Office for the Environment (FOEN).
- BKW Energy Ltd as owner of NPP Mühleberg.
- Canton of Bern.

Subgroups on

- technical aspects;
- legal procedure;
- communication.

The owner needs a decommissioning order from the granting authority (DETEC) for start-up the dismantling work.

Assessment of the decommissioning project (all documents for obtaining the decommissioning licence) by this institutions:

- Swiss Federal Nuclear Safety Inspectorate (ENSI).
- Federal Office for the Environment (FOEN).
- Occupational regulator (State Secretariat for Economic Affairs [SECO]).
- Canton of Bern.

The SFOE, authority for the lawsuit, requests for an expertise from every institution. The expertises are respected and get involved in the decommissioning order.

Licensing strategy used

The owner of a nuclear facility is to be obliged to decommission the nuclear facility if it has been definitively taken out of operation. The department orders the decommissioning and specifies which tasks require a permit to be obtained from the supervisory authorities.

The owner decided to dismantle the plant in three phases:

1. with fuel on-site (five years)
2. from fuel-free up to freedom of radioactivity (clearance level achieved and granted, 5 years)
3. documentation of performed dismantling and state of the plant and area for release from the Nuclear Energy Act (1 year)

Licensing documents for submittal to regulator (including support documents needed)

In relation to the decommissioning project pursuant to the Nuclear Energy Act, these documents must be submitted:

- phases and timetable for decommissioning work, decommissioning variants;
- individual steps of decommissioning work;
- procedure for separating radioactive and non-radioactive waste and management of radioactive waste;
- measures for radiological protection;
- security measures;
- accident analyses and emergency preparedness measures;
- human and organisational factors;
- management system;
- environmental impact report;
- total costs and securing of the financing.

Regulatory oversight during transition period

In accordance with the operation licence the regulator supervises the facility and assesses the measures for transferring the plant in a safe and stable condition for start-up of dismantling.

Public involvement/stakeholder engagements

Public

Decommissioning project (application document, final decommissioning plan, safety analysis and environmental compatibility report) is undergoing public consultation.

Federal Nuclear Safety Commission (NSC)

The NSC advises the Federal Council, the Federal Department of the Environment, Transport, Energy and Communications (DETEC) and the nuclear supervisory authorities on issues relating to the safety of nuclear facilities.

Decommissioning planning

Main strategies and approaches used

At the Nuclear-safety-regulator (ENSI) side:

In preparation for the huge decommissioning project the following implementations and measures were conducted:

- a new section for decommissioning was established;
- comprehensive supervisory concept of regulatory activities was implemented;
- technical guideline for decommissioning (ENSI G17) was implemented;
- monitoring group for external co-ordination of different stakeholders was established at the licensing authority;
- resource planning and training activities were updated;
- international co-operation was intensified.

ENSI ordered the owner after the shutdown-decision to submit a documentation by the end of 2014 about the planned measures for the transition period to transfer the plant in a safe state before dismantling can begin (supervisory procedures with ENSI).

At the plant owner side

A project team, which specifies the final decommissioning plan and worked out the decommissioning project (all documents for obtaining the decommissioning licence), was established.

Decommissioning strategy was worked out and decided: Prompt decommissioning with fuel on-site in the spent fuel pool.

A project for personnel management including staff-impact and staff-perspectives is conducted since 2015 (change management).

General

Regulator and operator get together frequently in technical meetings to talk about actual and planned activities.

Decommissioning scope, start and end point

Decommissioning scope is to dismantle all equipment of the plant in the technical buildings. The shell of the buildings will remain on the area. Further use of the buildings and the area will be concerned in a second lawsuit.

Dismantling can start after establishing of the measures for transferring the plant in a safe and stable condition (in transition period). Spent fuel can remain on-site in the first decommissioning phase.

The end of the decommissioning is reached, if the plant no longer presents a radiological hazard.

Requirement

Decommissioning includes all necessary activities for the plant to be used for other purposes, no longer presents a radiological hazard, and is thus no longer subject to nuclear supervisory.

Defueling and fuel logistics strategy

Defueling of the plant has the highest priority. The schedule for defueling is five years, because the fuel of the last core has to cool down in sufficient manner. The fuel will be packaged and transported in dry casks to the intermediate storage centre.

Guideline requirement

After the final shutdown, the nuclear materials shall be transported to another suitable nuclear installation. In particular, the fuel elements (or other forms of nuclear fuel in the case of research facilities) shall be transported to such a location as soon as reasonably possible.

In Switzerland exists a central intermediate storage for spent fuel and radioactive waste from all nuclear facilities.

Waste management strategy

The applicant has to describe the procedure for separating radioactive and non-radioactive waste and the management of radioactive waste, e.g.:

- The choice of decontamination methods must be assessed in terms of radiation protection, utilisation (recycling) of materials, reduction of the volume of radioactive substances and the production of secondary waste. The planned methods for clearance measurement must be presented in detail.
- The volumes of generated waste shall be estimated, for both types of radioactive and non-radioactive waste. In the case of inactive and cleared materials, conventional waste must be distinguished from hazardous waste.

The radioactive waste will be stored in the central intermediate storage centre up to the commissioning of the deep geological repository.

Social/economic impact

Human and organisational factors have to be addressed in the decommissioning project

- In particular, human resources required in the dismantling and for the necessary operation of the installation must be determined in the decommissioning project. These must be shown on a function-specific basis with the help of the planned decommissioning sequence. A concept for dealing with any delay in the time schedule must be provided.
- The organisational structure and the planned procedures must be described. The programme to take account of human and organisational factors must be presented, including methods for the design of working equipment, the work environment and processes.

Business strategy and financial provisions

Total costs and securing of the financing in accordance with Article 45, Nuclear Energy Ordinance

- The costs of decommissioning and waste management as per Article 2 and Article 3 of the Ordinance of Decommissioning and the Nuclear Waste Disposal Fund, respectively, must be determined in the decommissioning project under consideration of internationally recognised methods.

Financial provisions have to be done in accordance of the Ordinance on the Decommissioning Fund and the Waste Disposal Fund for Nuclear Installations.

Decommissioning organisation and staffing

Corporate and decommissioning site organisations and interactions

Responsibility remains at the plant owner. The plant manager remains in the position with the highest responsibility (safety-oriented). It's foreseen to conduct the dismantling by both, staff and contractors (for special tasks)

Planning, implementation and project management approach for optimisation

A dismantling project division, responsible for execution of dismantling, will be implemented in the plant organisation.

Experience and knowledge management methods

Not applicable at this juncture

Preparation and training of decommissioning staff

Not applicable at this juncture

Projects conducted during transition period

Initial site characterisation

Characterisation data from the operation period exists. The site characterisation is going on and will be updated before and after shutdown of operation. Especially the data from difficult accessible structures and components will be analysed and recorded after shutdown.

System and building decontaminations

Partly decontamination of some systems and components are foreseen (full system decontamination is probably not required). This depends on the radiological level after shutdown.

Up to now the plant have only a small damage of one fuel element. Therefore the primary system operates in a low radiological level.

Buildings (controlled area) will be decontaminated up to the level for clearance. Buildings (non-controlled area) and the surrounding area will be measured by random sampling

Asset management

The costs for transition phase and operational waste are borne by the owner. The owner should set up accruals.

The costs for decommissioning are covered by the decommissioning fund. This fund is controlled by an independent commission. The owner has to pay yearly contribution to the fund.

Disposition of operational waste

The disposition is going on in the last years of operation and during the dismantling phase. Treatment of the waste is possible at the plant and at the intermediate storage centre.

Technology and technical requirements – preparations for dismantlement projects

Not applicable at this juncture, planning is going on

Lessons learnt

Positive

The implementations and measures in preparation for the decommissioning of the plant were very helpful to clear most questions and problems on both sides – regulator and operator.

The requirements from the regulator side could be discussed and explained, which was helpful for planning the decommissioning project and finalising the final decommissioning plan.

The operator was able to present its actual planning and discuss the handling of these.

Negative

Will come after start of the dismantling phase.

Annex A.7. United Kingdom – Case study: THORP Transition from operations, post-operations clean-out

Plant description

The Thermal Oxide Reprocessing Facility (THORP) is located on the Sellafield site and started operations in 1997. It is currently operational although its owners are planning now for its final shutdown in 2018.

Spent fuel from the UK advanced gas reactors (AGRs) and other materials are reprocessed within THORP with the objective of extracting the materials such as Uranium and Plutonium which can then be reused as required. The cooled oxide fuel is chopped into pieces (sheared) before the fuel is dissolved in nitric acid and chemically separated using solvent extraction. The facility is complex, and has many connected facilities both upstream and downstream such as effluent and other waste treatment facilities and these need to be decoupled as part of transition.

The transition phase in this context is intended to end with a handshake to the start of the decommissioning programme. Historically, the management of such transition phases on the Sellafield site has been sub-optimal, and to ensure this is not repeated a dedicated team has been established with the objective of planning the transition phase.

The transition approach

It is intended that the incumbent plant operators will be used to complete as much of the post-operations clean-out as possible to make use of their plant knowledge, experience and skills. This part of transition has the objective of the removal of as much of the radioactivity, chemical and other hazardous materials as possible from the facility. The objective of this phase of transition is to leave the plant in a safe, quiescent and well understood configuration in preparation for decommissioning, as well as making best use of the normal established plant processes, waste routes and reagents.

Preparations for transition have started, and the primary aims have been established as:

- risk and hazard reduction;
- enabling redeployment of resource and capability from THORP to other locations;
- reduction in life cycle costs;
- looking for opportunities to maximise the reduction in inventory during transition by making best use of the operational systems, processes and procedures and the knowledge of the plant operators.

A key output of transition is judged to be knowledge in the form of plant configuration which will enable the safe and efficient decommissioning of the facility. The operator has developed an outline transition plan with the objective of enabling a smooth transition from operations through to the start of decommissioning. A key part of transition will be the post-operations clean-out, which has the following objectives:

- remove as much of the radioactive inventory from the plant as possible;
- remove chemical and other hazardous materials from the plant;
- leave the plant in a passively safe condition suitable for optimal decommissioning to start;
- define the detailed sequence of decoupling the plant from other site facilities;
- define and implement a managed reduction of manpower suitable for both an initial surveillance and maintenance phase, followed by further reductions as required in preparation for the decommissioning phase.

It is expected that the operational safety case will need to be modified during transition to support operations associated with the post-operations clean-out.

To enable successful transition, a number of success factors have been defined, which can be measured at the end of transition:

- Plant configuration is known, documentation and recorded in such a way that enables efficient decommissioning.
- The Plant Safety Case has been reduced in scope to reflect cessation of operations (including the post-operations clean-out), the technical specification has been issued.
- All wastes from the post-operations clean-out phase have been removed from the facility, or waste routes as required for their complete removal are in place.

- The knowledge management process has been completed.
- The organisational transition has been completed, probably in a phased manner, such that it is suitable for surveillance and maintenance and the start of decommissioning if required.
- Regulators and other stakeholders support the post operational status for each facility, and support the handshake to the decommissioning phase.
- Any systems not required by the safety case have been deactivated.

Regulatory process

In the United Kingdom, a nuclear site licence is issued to the owner of a nuclear site (the "body corporate") which permits the defined site to be used for specified activities. As such, the licence remains in force from operations through to the completion of decommissioning and ultimate revocation of the licence, and a specific decommissioning licence is not required. The regulatory process is based on UK primary legislation requiring that risks are reduced to as low as is reasonably practicable which is termed the ALARP principle. This requirement ensures that relevant good practice and appropriate standards are applied throughout the nuclear life cycle, including transition through to decommissioning.

A number of conditions are attached to each site licence, and under these conditions arrangements and actions by the licensee which are judged by the regulator to have nuclear safety significance may require prior regulatory permission before work commences or changes are implemented. The UK nuclear regulatory regime is therefore described as a permissioning regime, and as such the regulator may impose regulatory hold points at key life cycle points such as the commencement of decommissioning. Such a hold point would normally be accompanied by the submission by the licensee of a safety case, and the licensee cannot proceed beyond without formal regulatory permission which would be based on a regulatory view of the adequacy of the safety case.

Safety case

It is expected that the operational safety case will need to be modified during phases of post-operations clean-out to accommodate additional activities. Following completion of the post-operations clean-out the safety case will be further modified and reduced in scope with accompanying changes to the technical specification, engineering schedules and safe operating envelope which will reflect the reduction in hazardous inventory.

Management of radioactive wastes

During transition, waste export and processing routes are intended to be as if the plant were fully operational. A key success factor of the transition phase is that the waste remaining within the facility at the handshake to the start of decommissioning is characterised such that its properties and required waste route is known. This reduces the potential for the generation of 'orphan' wastes, those waste processing routes are either unavailable or unknown.

Reference

MacPherson, I. and A. Dunlop (2016), "Development of a Systematic Approach to Post Operations Clean Out (POCO) at Sellafield", Sellafield Limited as presented at PREDEC 2016, 16-18 February 2016, Lyon, France.

Annex A.8. Spain – Case study: Decommissioning of José Cabrera NPP

Background

Decommissioning strategy:

Immediate dismantling

Schedule:

Operation: From 1969 to 2006*

Transition: From 2006 to 2010

Decommissioning: Since 2010

Actual status:

Dismantling of systems. Reactor vessel internals and large components have been dismantled. Currently works are focused on the decontamination of concretes, the demolition of buildings and the site restoration.

Waste "interim" storage/national repository (available or not):

El Cabril National Repository, for LILW and VLLW and the on-site independent spent fuel storage installation for special waste class and spent fuel.

Experience in transition from operations to decommissioning in other projects:

Vandellós 1 NPP. The Vandellós I gas cooled-graphite reactor was decommissioned in about five years (from 1998 to 2003) to what was known as level 2 of IAEA.

* October 2002: Publication of permanent shutdown in 2006.

José Cabrera NPP site

Decommissioning preparatory activities

Summary

Organised decommissioning planning. Start-up of an extensive set of decommissioning preparatory activities under both the operational license (operation and transition periods) and decommissioning licence.

	Operational licence		Decommissioning licence
	Operational stage	Transition stage	Decommissioning stage
Planning, engineering and licensing of project	X	X	--
Radiological characterisation and radiological database	X	X	X
Conditioning operational waste	X	X	--
On-site independent spent fuel storage installation (ISFSI) and spent fuel cask licensing. Unloading spent fuel from reactor pool and storage at the ISFSI	X	X	--
Decontamination of primary system	--	X	--
Discharge of systems, equipment and structures not required for dismantling, including removal of hazardous waste and drainage systems	--	X	X
Personnel training and adapting organisation to D&D	--	X	X
Modifications of existing systems or design of new ones to support dismantling activities (ventilation, fire protection and electrical systems)	--	--	X
Construction/renovation of auxiliary facilities and preparation of work areas to support dismantling activities (refurbishment of the turbine hall building as the decommissioning auxiliary building, upgrade in the radwaste storage area)	--	--	X
Dismantling of conventional elements (cooling towers, diesel generator building, transformers and disassembling of the control room)	--	--	X

Planning, engineering and licensing of project

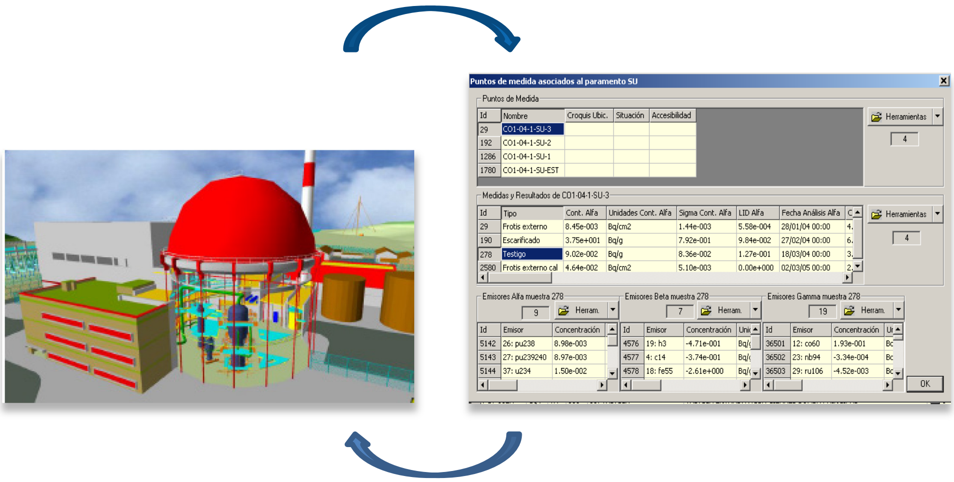
The planning for decommissioning began in 2003, once the date for the José Cabrera's permanent was known. During this period the following tasks were carried out:

- **Basic strategy study** for the facility to be dismantled: the Study included the physical and radiological inventories, costs of dismantling and proposed the preferred decommissioning option.
- **Basic engineering and licensing documentation:** Preparation of the basic engineering and licensing documentation required by Spanish law for the authorisation for decommissioning, considering the strategy chosen.
- **Detail engineering:** engineering tasks and design activities for specifying the various tasks involved in site preparation, and setting out their tendering requirements.

In parallel to this, the licensing process for obtaining the authorisation for decommissioning was carried out with the competent authorities. This included a review of the mandatory documents.

Radiological characterisation and radiological database

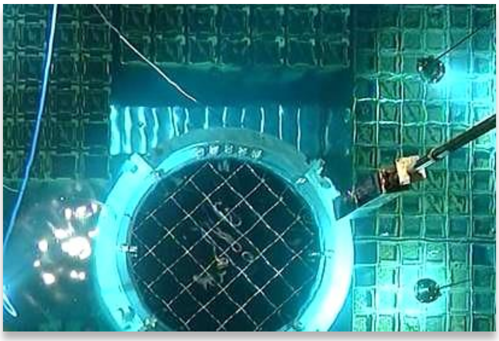
One of the most important steps in decommissioning planning was the radiological characterisation of the facility. Characterisation activities began when the plant was in operation, and they have continued during the decommissioning period. The scope of characterisation activities included not only the installation but also the environment that may have been affected by the facility´s operation. A radiological database was developed to store all radiological data from the beginning of the site radiological characterisation.



On-site independent spent fuel storage installation (ISFSI)

In 2009 spent fuel was removed from the pool and it is currently stored in 12 casks at an on-site independent spent fuel storage installation (ISFSI).

José Cabrera ATI

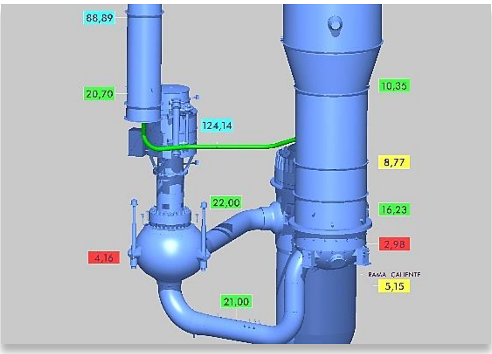


Loading spent fuel into the cask.

Independent spent fuel storage installation.

Decontamination of primary system

During the shutdown stage decontamination of the primary circuit was carried out in order to reduce worker exposure during decommissioning activities. During decommissioning, after the disassembly of the large components at the José Cabrera plant, it was shown that there was a highly significant dose reduction to the workers.



Primary system decontamination.

Modifications of existing systems or design of news to support dismantling activities

During 2010 and 2011, modifications of existing systems or design of new systems to support dismantling activities were carried out. These activities were performed according to the **system modification plan**.

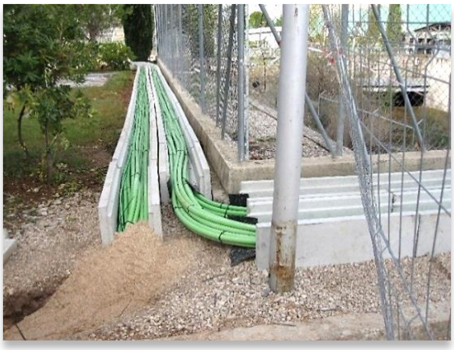
The electrical system was modified. This included the installation of a new electrical supply adapted to the needs of the decommissioning process. The water supplies (fire protection system, general services and dilution effluents system) and the ventilation system of the reactor and auxiliary building were also adapted to the new situation.

New fire protection pumps.

Fire protection system modification.

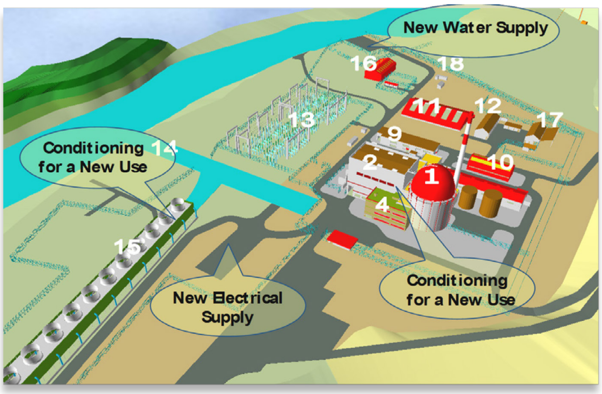
Ventilation system adaptation.

New portable filtration unit.



Electric supply system modifications.

New electrical building.



Discharge of systems, equipment and structures not required for dismantling, including removal of hazardous waste and drainage systems

All systems were deactivated (drained and/or de-energised) prior to equipment removal and the potential isolation point of others systems required to support decommissioning activities. These activities were performed according to the discharging system plan. Discharging of system started during shutdown period and continued during the decommissioning stage.

According to the reduction of risks plan, inflammable or toxic products that might pose a problem during the works were removed from the plant.

Discharge of components prior to dismantling.

Construction/renovation of auxiliary facilities and preparation of work areas to support dismantling activities

At the beginning of decommissioning period, all the components from the turbine hall were removed and several civil works were carried out to transform the building as the new Decommissioning auxiliary building for the treatment and storage of the radioactive wastes to be generated during the dismantling of radiological areas. Subsequently cutting and decontamination workshop has been set up in this building.

Warehouses to store wastes arising from dismantling activities were improved and adapted. Likewise, an area was enabled for the clearance of materials.

These works were carried out according to the conditioning auxiliary facilities plan.

Refurbishment of the turbine hall building as the decommissioning auxiliary building

Initial status of the operational plant.

Dismantling of the turbine components.

Dismantling of the turbine components.

Current status of the decommissioning auxiliary building.

Waste storage modifications and clearance area preparation

Waste storage upgrading.

Clearance area.

Dismantling of conventional elements

According to the disassembly of non-radiological systems plan, some conventional dismantling activities relating to infrastructures that did not have any radiological connotation were performed.

Among the most significant buildings and facilities in this group were the diesel building, the electrical transformers and the cooling towers. Cooling towers were demolished to reuse this zone as a temporary storage area for conventional scrap before dispatching it from site.

Demolition of cooling towers

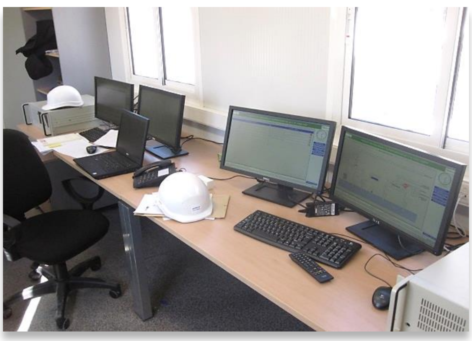
Diesel generator building

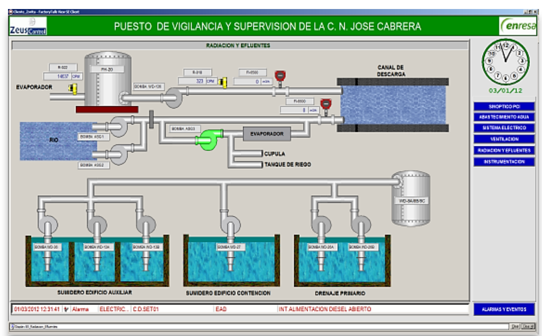
Dismantling of components.

Diesel generator building converted into an auxiliary storage area.

Disassembly of the control room

New control room for decommissioning





Regulatory framework

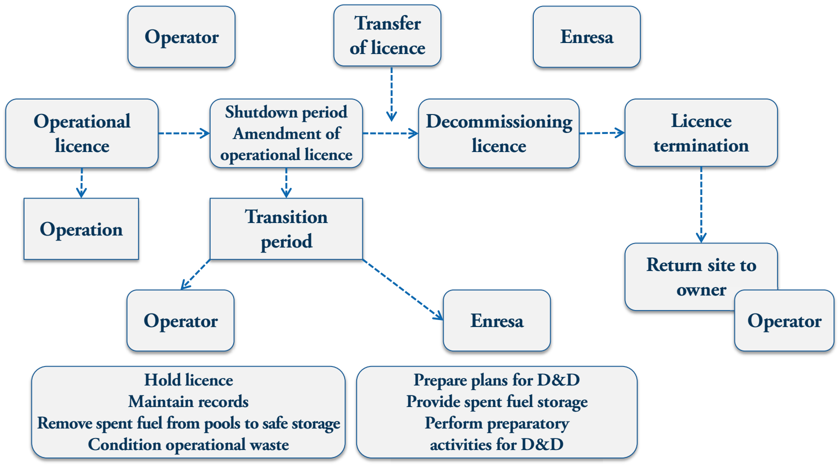
Regulator/types of licences required

Responsibility for decommissioning of nuclear facilities in Spain lies with the National Radioactive Waste Company (Enresa).

When a nuclear facility ceases operation, the holder of the operating licence is responsible for the post-shutdown activities. These may include preparatory activities for decommissioning. For the purposes of Spanish legislation, the permanent shutdown phase constitutes an amendment of the operating permit.

In order to be granted with the authorisation for decommissioning, the holder of the operating licence must already have conditioned the operational radioactive waste generated. They must also have unloaded the fuel from the reactor and spent fuel storage pools or, at least, have a plan for spent fuel management approved by the Ministry of Energy, subject to a report from the Nuclear Safety Council (CSN).

Enresa's responsibility is to draft and submit for approval to the Ministry of Energy the decommissioning plan for each nuclear power plant, following shutdown, in order to obtain the authorisation for decommissioning and the transference of the licence from the operator to Enresa.



José Cabrera main licensing dates

Authorisations required for decommissioning and dates for José Cabrera NPP

Competent authority			Licence	Date
National	Ministry of Energy	Nuclear Safety Council	Decommissioning authorisation and ownership transference to Enresa	February 2010
		Nuclear Safety Council Ministry of the Interior	Physical protection nuclear material authorisation	February 2010
		Ministry of Environment	Environmental impact statement	December 2009
	Local authority		Work licence project	February 2010
European	European Commission		Data required Art. 37 and 41 Euratom	July 2009

Licensing strategy used

- Amendment to the operating licence for the transition period: included some preparatory activities for D&D (decontamination of the primary system, radiological characterisation, discharge of systems, dismantling of conventional components) and construction of the independent spent fuel storage installation (ISFSI).
- Before shutdown, draft of licensing documents for decommissioning was submitted to the Regulatory Authority in 2005 Final version of licensing documents was submitted in 2008, two years after final shutdown.

Licensing documents for submittal to regulator (including support documents needed):

Decommissioning authorisation

- Ministry of Energy and CSN:
  - Safety report, including the following information:
    - Selected strategy and plan for decommissioning. Facility and site description.
    - Description of the radiological initial state and radiological characterisation of the site. Physical and Radiological inventory.
    - Design criteria, safety functions and their associated structures, systems and components.
    - Description of facilities, structures and systems needed to carry out the decommissioning project.
    - General decommissioning project and end state. Activities and Plans description.
    - Safety assessment, including the applicable safety and radiological regulations and criteria, as well as the identification of risks under normal operational and accident conditions, and preventative measures to be adopted.
    - Industrial Risks. Prevention measurements and Emergency measurements.
    - Assessment of the Environmental radiological impact and radiological monitoring programme for implementation during the dismantling.
    - Organisation and responsibilities, qualifications of personnel, training, procedures and quality assurance.
  - Technical specifications, for the equipment and systems which were to be kept operational and which were significant for nuclear safety. The requirements for technical specifications of some of the safety system were downgraded to reflect the risk level of the decommissioning and some specifications were removed. Systems that were important for radiological protection purposes were regulated by means of surveillance programmes, which were referenced in this document. Only technical specification referred to ISFSI remained in this document.
  - Operating Regulations, which included description of the organisation and responsibilities of personnel involved in the dismantling activities, including the number of required operating licences.
  - Quality assurance manual establishing the scope and content of the quality assurance programme designed for the project.
  - Radiological protection manual, including the organisation, standards and criteria for radiation protection.
  - On-site emergency plan detailing the organisation and measures planned to address potential accident situations during decommissioning.
  - Radioactive waste management and spent fuel management plan, including the management criteria and strategy for all radioactive waste generated during decommissioning.
  - Plan for material clearance, a specific document to the decommissioning process, which contains the guidelines and methodology for verifying compliance with criteria for clearance of the materials generated during decommissioning.

- Site restoration plan, a dedicated document that should include the initial radiological site characterisation, the projected final scenario, radiological criteria for the site release and the methodology for the final radiological survey.
- Economic study including the cost estimates for the decommissioning project.

▪ CSN:

- Monitoring programmes, ventilation system, fire protection system, other systems –Electrical, Radwaste management, Meteorological and Seismic systems-), Off-Site Dose Calculation Manual and Environmental Radiological Surveillance Program.
- Environmental impact report (Ministry of Energy and MAGRAMA): Assessment of conventional environmental impact (non-radiological), monitoring programme and preventative measures to be implemented during the decommissioning works. Impacts are: noise, dust, vibration, environmental impact on flora and fauna caused by dismantling works.
- EURATOM requirements: Data required by art. 37 and 41. Nuclear Safeguards.
- Others permits: work licence permit (Town Hall), physical protection authorisation (Ministry of Energy and Ministry of the Interior) and water discharge permit (MAGRAMA).
- CSN: Nuclear Safety Council, MAGRAMA: Ministry of Agriculture, Food and Environment, MI: Ministry of the Interior.

Regulatory oversight during transition period:

- Monitoring activities: 1 On-site inspector (resident inspector), baseline inspection programme (annual) and specific inspection programme depending on the significance of the ongoing activities.
- Evaluation activities: licensing documents and requirements involved in the authorisation process.

Public involvement/stakeholder engagements:

- The decommissioning project and the draft environmental impact report are made available to the public before the approval. The public is allowed to comment on the environmental issues of the project.
- Environmental authorisation was subjected to public consultation. Scoping was made by the MAGRAMA with consultation to stakeholders, local, regional and national authorities.

Decommissioning planning

Main strategies and approaches used

Complete and immediate dismantling to be initiated four years after a shutdown (transition period including the decontamination of the primary system).

Decommissioning scope, start and end point

Complete dismantling of the facility after the removal of the spent fuel from the pool and conditioning of operational waste by the operator. Restricted site release as industrial scenario.

Activities were grouped as follows:

- preparatory activities;
- dismantling and decontamination of:
  - large components;
  - radiological systems.
- decontamination and demolition of buildings and structures (pool and biological shielding);
- site restoration;
- waste management.

Plans were developed to carry out the above activities:

- discharging system plan, reduction of risks plan, system modification plan, conditioning auxiliary facilities plan, disassembly of non-radiological systems plan (preparatory activities);
- radioactive systems dismantling plan;
- large components dismantling plan;
- decontamination of building plan;
- demolition and filling plan;
- site restoration plan;
- waste management plan (radwaste, material clearance and hazardous waste).

Licence termination: last licensing action will be the application of the licence termination.

Defueling and fuel logistics strategy

Construction of an on-site independent spent fuel storage installation (ISFSI). During transition period the spent fuel was removed from the pool, transferred to 12 casks HI-STORM 100Z and stored at the ISFSI. During decommissioning, four additional casks for special waste – similar to the US GTCC class – have been stored next to spent fuel at the ISFSI.

Waste management strategy

On-site conditioning of LILW and VLLW to be later dispatched to El Cabril Spanish Repository.

Waste conditioning is based on the results of the characterisation and its compliance with the acceptance criteria: El Cabril's Waste Acceptance Criteria, RP-89 and RP-113 for clearance, DCGL for soils at the moment of site release.

Waste minimisation and volume reduction are considered as good practices.

Social/economic impact

An average workforce of 200 professionals during decommissioning, this to be adapted to the needs of the project.

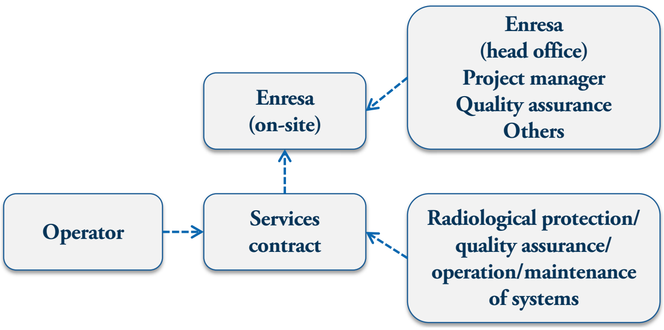
Business strategy and financial provisions

Decommissioning costs covered by the financial resources of the fund managed by Enresa (sources for contribution to the fund are regulated).

Decommissioning organisation and staffing

Corporate and decommissioning site organisations and interactions

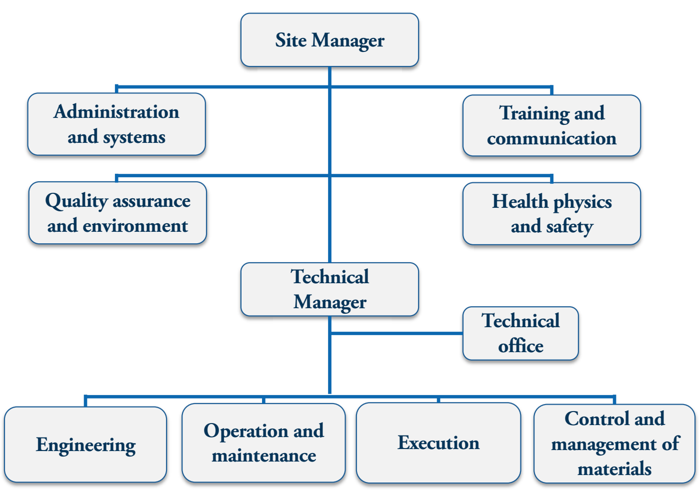
Enresa manages the project having taken over the nuclear licence from the operator and having its own team/staff on-site.



Enresa controls key positions of on-site organisation (Site Manager, Technical Manager, Radiation Protection and Safety Head, Administration head, Quality Assurance Head, Engineering Head and Communication and Training Head) by having a highly specialised and limited in number team. The project has intensive support from Enresa head office.

Enresa set out a services contract with the former operator, under which approximately 50 personnel of the former operator continued working. Also, Enresa hires services as radiation protection, maintenance, waste management, and hires specialist companies for specialised activities (internals segmentation, decontamination and demolition works). Personnel who continue working from operation to the dismantling must be trained with regard to the new positions and duties.

Decommissioning site organisation is based on a Site Manager and Technical Manager and some technical services that depend on either. On-site organisation interacts with the corporate one through the Project Manager who co-ordinates with the Technical Manager.



Planning, implementation and project management approach for optimisation

Look D&D as a project. Use project management tools to monitor and control progress of activities:

- design of the organisation during decommissioning (organisation chart, functions of the areas, personnel required, engagement process, etc.);
- "implementation plan" with the participation of several departments of Enresa in order to be prepared to become the licensee of the site;
- preparation of operational procedures;
- planning and update of decommissioning schedule and programme;
- use of specialised contractors to implement the dismantling activities.

Experience and knowledge management methods

D&D requires an appropriate combination of experienced workers with operational memory and new workers with D&D experience. Transfer of key personnel from operational staff to decommissioning staff and use of specialised contractors.

To hold Meetings of "lessons learnt" and to perform operational experience reports

To adapt and reuse methodologies developed in previous projects.

To participate in international groups (NEA, IAEA, bilateral, etc.) to share experiences and benchmarking.

Preparation and training of decommissioning staff

New organisation integrating new competences and operating personnel requires a complete training programme during transition period. General Training, Occupational Training (based on-the-job qualification) and retraining programmes.

Besides, an specific training program is continuously being adapted to the progress of the decommissioning project.

Projects conducted during transition period

Planning, Engineering and Licensing of Project (O&T), radiological characterisation (O,T&D), conditioning operational waste (T), removal of spent fuel from reactor and pool (T), discharge of systems, equipment and structures not required (T&D), decontamination of the Primary Circuit (T), Defueling (construction of ISFSI and transfer of 12 casks with spent fuel to ISFSI) (T), personnel training and adapting organisation to D&D (T&D), modifications existing systems or design of news to support dismantling (D) and construction/renovation of auxiliary facilities and preparation of work areas (D).

O: Operation Period; T: Transition Period and D.: Decommissioning Period

Initial site characterisation

Six campaigns for radiological characterisation were carried out covering both operation, transition and decommissioning stages.

Radiological results and applications:

- radiological inventory;
- dismantling activities;
- radiological impact;

- parameters for final survey;
- assessment residual activity.

System and building decontaminations

Chemical decontamination of the primary system.

Lessons learnt

Positive:

- start planning and preparation of D&D already under the last years of operation.
- co-operation with the operator facilitates the transition to the D&D;
- fluid and transparent communication with the authorities may shorten approval times;
- new challenges must be addressed (relocation and integration of personnel, knowledge retain and transference);
- radiological characterisation "prior" and "during" the transition period is a key element for planning the decommissioning project.

Negative:

- regulations on decommissioning have to be adapted to the risks during decommissioning;
- plant records and as-built documentation are generally not complete;
- old incidents are usually not well reported.

References

Correa, C. (2016), "Decommissioning Licensing Process of Nuclear Installations in Spain", PREDEC 2016, 16-18 February 2016, Lyon, France.

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Rodríguez, M. (2012), "Organizational and contractual approach: Decommissioning of José Cabrera NPP", SNF Meeting, December 2012.

Santiago, J.L., Martín, N. and Correa, C. (2013) "Marco general y bases de los desmantelamientos de las instalaciones de las instalaciones nucleares", Revista Radioprotección n° 76, Vol. XX.

Annex A.9. United States – Case study 1: Connecticut Yankee NPP decommissioning

Reference: Guidance for Transition from an Operational to Decommissioning Status for Nuclear Power Plants (2016) EPRI # 3002007551, 3412 Hillview Avenue, Palo Alto California, 94304.

Background

Decommissioning strategy:

Prompt Dismantlement

Schedule:

December 1996 to November 2007

Actual status:

Final plant shutdown in December 1996. Transition activities took approximately three years to complete. Plant site released from NRC licence in a greenfield state except for a small dry fuel storage facility (1 hectare).

Experience in transition from operations to decommissioning in other projects:

Shutdown was unexpected and premature and so no planning for decommissioning had been done. This delayed the start of active decommissioning.

Decommissioning preparatory activities

Summary

Table below shows major decommissioning activities including regulatory submittals. Other major tasks during transition period are shown in Section 2.4.

Period	Dates	Key event
Operation	22 July 1996	Last day of power operations
	15 November 1996	Defueling complete
	4 December 1996	Decision to permanently cease operations
Transition period	5 December 1996	Shutdown announced/defueled certification to NRC
	January 1997 to July 1998	Initial decommissioning planning/site scoping survey
	May 1997 to July 1998	Improved health physics programme development
	August 1997	PSDAR submitted
	Late 1997	Decommissioning public meeting

Period	Dates	Key event
	Late 1997 to late 1999	Initial site characterisation and historical site assessment
	1998-1999	Bulk asbestos insulation removal
	January 1998	DSAR submitted
	May 1998 to September 1998	Full system chemical decontamination
	June 1998	Operating licence amended to reflect permanent shutdown
	1998	Fuel building upgrade complete
	April 1999 to July 2003	Subcontracted to decommissioning operations contractor
	October 1999	Operating licence amended to reflect decommissioning
Decommissioning period	Late 1999	Steam generator and pressuriser removals
	March 2000 to August 2002	Reactor vessel internals segmentation project
	July 2000	Licence termination plan submitted
	November 2000	Site characterisation report submitted to NRC
	November 2003	Licence termination plan approved
	July 2003 to January 2004	Reactor pressure vessel package preparation and shipment
	April 2004 to March 2005	Transfer fuel and GTCC to ISFSI pad
	September 2004 to July 2006	Major building demolition
	December 2005	Subsurface soil remediation complete
	December 2005 to January 2007	18-month groundwater monitoring period for NRC
	March 2007	Final status survey/physical work complete
	November 2007	NRC licence terminated for all non-ISFSI areas

Regulatory framework

Regulator/types of licences required

NRC is lead regulator for radiological site release but state authorities can be more restrictive. The US Environmental Protection Agency or state agency oversees non-radiological site release.

No decommissioning licence but other submittals that must be submitted and/or approved by NRC:

- PSDAR – High-level description of the decommissioning – No NRC approval needed.

Major revisions or new documents which require NRC approval:

- safety analysis report – decommissioning accidents and new plant design basis;
- technical specifications;
- emergency plan;
- security plan;
- spent fuel management plan;
- licence termination plan – basis for radiological release of the site and funding adequacy.

Licensing strategy used

Prepare licensing documents as quickly as possible by using personnel with experience during other power plant decommissioning.

Regulatory oversight during transition period

On-site resident NRC inspector until shortly after final shutdown. Then periodic visits for inspections. Periodic visits by State regulators.

Public involvement/stakeholder engagements

Established a Community Decommissioning Activities Council consisting of local community stakeholders and held frequent meetings.

Decommissioning planning

Main strategies and approaches used

Minimise cost by completing decommissioning as quickly as possible. Created a Spent Fuel Pool Island so that other dismantle work could be conducted while the fuel was still in the fuel pool.

Decommissioning scope, start and end point

Dismantle and decontaminated site to a greenfield state.

Defueling and fuel logistics strategy

Fuel Building modified to be a Spent Fuel Island. Fuel moved to dry storage as soon as decay allowed meeting of dry fuel storage canister heat load limits. No repository or off-site storage currently available.

Waste management strategy

Waste disposal sites available so waste was shipped off-site as quickly as possible. Rip and ship of contaminated systems and structures. Little decontamination of equipment or above ground structures performed. One piece disposal of reactor vessel at Barnwell site accomplished.

Social/economic impact

Significant economic impact of community. Loss of jobs and property tax revenue.

Business strategy and financial provisions

Minimise cost by completing the decommissioning as quickly as possible.

Decommissioning organisation and staffing

Corporate and decommissioning site organisations and interactions

As this was a single power plant utility, all of the decommissioning organisation was on-site. Primary departments were: Decommissioning Project, Radiation Protection, Oversight, Finance, Industrial Safety, Security.

Planning, implementation and project management approach for optimisation

Use detailed schedule and Earned Value Management System to control cost and schedule.

Experience and knowledge management methods

Hire experienced persons for key management and staff positions. Retain key employees. Conduct exit interviews as long-term employees leave the site.

Preparation and training of decommissioning staff

Utilise staff with experience at other sites to mentor retained operating plant staff and/or benchmark/compare notes with other decommissioning plants.

Projects conducted during transition period

Initial site characterisation

A historical site assessment (HSA) was developed to serve as a basis for the initial site characterisation. The HSA development effort took about four (4) person-years to complete. It is very important to perform this assessment early in decommissioning to direct characterisation efforts and to help determine how certain aspects of the decontamination should be conducted. The initial characterisation effort began in late 1997 and was completed in late 1999. The initial characterisation was performed to the guidelines of MARSSIM.

System and building decontaminations

- A full system decontamination was conducted during the transition period. Systems included in the decontamination include the reactor coolant system (RCS), Chemical and Volume Control System, Residual Heat Removal System and RCS fill and drain system. The internal surfaces of the Reactor Pressure Vessel and about 85-90% of the Steam Generator tubing were not included in the decontamination.
- Little decontamination was done to above ground Radiological Control Area structures as they were totally demolished and all debris shipped as radioactive waste.

Asset management

Unknown by typically little sale of plant items due to contamination.

Cold and dark

Establishing "cold and dark" conditions refers to de-energising, depressurising, and draining all systems of the plant that are no longer needed for decommissioning. These activities were conducted during the Connecticut Yankee transition period.

Experiences at previous decommissioning sites with establishment of cold and dark conditions indicated that immediate shutdown of all plant systems could lead to problems. For example, shutdown of all plant systems led to condensation inside containment at a different plant, which resulted in unsafe work conditions. To reduce the potential for such issues, Connecticut Yankee repowered certain systems that were needed for decommissioning. This included repowering the heating, ventilation and air conditioning (HVAC) systems. To supply power to these systems, a new power source was brought to the plant. Bright orange striped cabling was used to help identify which power cabling was energised.

Emergency power

No emergency power after early portion of the transition period. Power for site activities provided by standard "Street power".

Disposition of operational waste

Disposal sites available. Waste shipped to these sites as they had been during plant operation.

Technology and technical requirements – preparations for dismantlement projects

Preparations for projects such as large components shipments and reactor vessel internals segmentation begun during transition period.

Asbestos removal

Approximately 500 000 lbs of asbestos were removed during the Connecticut Yankee decommissioning. A large portion of this removal occurred during the transition period. It is beneficial to conduct asbestos removal early in decommissioning because asbestos removal generally requires the use of enclosures.

Hot spot reduction

Hot spot reduction consists of identification and subsequent removal of components or parts of components with high dose rates. Like full system chemical decontamination, it is beneficial to conduct hot spot reduction early during decommissioning to maximise dose savings from later decommissioning activities. Hot spots were identified and, where possible, removed during the transition period after the decontamination application. However, many hot spots were located in components/systems required to maintain the reactor cavity water boundary. These hot spots could not be removed until many other components had been removed, including the reactor vessel internals.

Lessons learnt

Positive results

Transition activities after permanent shutdown:

- The human resource issues related to the shutdown of a nuclear plant need to be addressed immediately after the decision has been made to permanently shut down a plant. This will help to avoid personnel errors and injuries that could result from distracted workers.
- A plan needs to be developed to retain key employees that have the institutional knowledge of the plant needed during the decommissioning. Additionally, the decommissioning organisation needs to bring in individuals with decommissioning experience.
- The transition period is the most efficient time to perform early decommissioning projects such as Asbestos Abatement and Full System Chemical Decontamination.
- It is critical to prepare the historical site assessment for the facility at this time if it has not already been prepared.
- It is advised that the chemical decontamination be conducted shortly after the last shutdown while maintenance schedules have continued to be followed on equipment to be utilised and experienced operations personnel are still present

on-site. This early application also maximises the benefit of the chemical decontamination.

- The ratio of alpha radionuclides to the beta and gamma radionuclides in the contamination at a plant can greatly increase the complexity and cost of controlling exposures during a decommissioning.

Difficult challenges

Preplanning for decommissioning (before permanent shutdown):

- Many of the planning activities for the decommissioning of a plant can be conducted well in advance of the actual permanent shutdown. The high-level strategy for the decommissioning should begin when the possibility of decommissioning is being considered.
- Maintain a comprehensive historical site assessment (10 CRF 50.75 [g]) file of contamination events during operation. This will facilitate planning once the decommissioning is scheduled.
- Once the permanent shutdown is scheduled, the detailed planning, engineering and early project specifications should begin in earnest approximately one year before permanent shutdown. This will avoid the delays in beginning dismantlement activities that was experienced at Connecticut Yankee.
- Perform high-level strategic planning for the major decommissioning projects such as reactor internal/vessel segmentation and full system decontamination. This will avoid a delay in beginning the decommissioning activities at the start of the decommissioning.

Annex A.10. United States – Case study 2: Vermont Yankee NPP decommissioning

Reference

Guidance for Transition from an Operational to Decommissioning Status for Nuclear Power Plants (2016) EPRI # 3002007551, 3412 Hillview Avenue, Palo Alto California, 94304.

Background

Decommissioning strategy:

Safe Storage then Decom

Schedule:

Complete by December 2074

Actual status:

Final Plant Shutdown in December 2014. Transition activities are essentially complete. After transition, plant will be in safe storage status until sufficient decommissioning funds are collected to complete the decommissioning but decommissioning will be completed no later than 60 years after the final shutdown date per NRC regulations. Spent fuel transfer to dry fuel storage will be completed by the end of 2018. Sale of the plant to the Northstar partnership has been proposed and is pending regulator approval. Under this proposed sale, dismantlement would begin after completion of fuel transfer and be completed within 10 years of closing the sale.

Experience in transition from operations to decommissioning in other projects:

Site knew the permanent shutdown date 16 months prior to the actual final shutdown. This allowed many transition activates to be completed prior to the final shutdown and reduced the post-shutdown transition period to only 16 months. Plant is positioned to move into active decommissioning when sufficient funding is achieved or the proposed sale is finalised.

Decommissioning preparatory activities

Summary

Table in Section A.7.2.1 below shows all of the regulatory submittals made by Vermont Yankee. Much of the preparatory activities that have been done to date are the preparation of these submittals.

Additional preparations for safe storage period:

- expansion of the dry fuel storage facility to accept all the fuel by the end of 2018;
- developed a plan for human resources for entire decommissioning;
- established a nuclear decommissioning community advisory panel.

Regulatory framework

Regulator/types of licences required

NRC is lead regulator for radiological site release but state authorities can be more restrictive. The US Environmental Protection Agency or state agency oversees non-radiological site release.

No decommissioning licence, but other submittals that must be submitted and/or approved by the NRC:

- Post-shutdown decommissioning activities report (PSDAR) – High-level description decommissioning – No NRC approval needed.

Major revisions or new documents which require the NRC approval:

- safety analysis report – decommissioning accidents and new plant design basis;
- technical specifications (TS);
- emergency plan;
- security plan;
- spent fuel management plan (SFMP);
- licence termination plan – Basis for radiological release of the site and funding adequacy.

Licensing strategy used

Prepare and submit many licensing documents prior to final shutdown to minimise length of post-shutdown transition period.

Licensing documents for submittal to regulator (including support documents needed)

Regulatory submittals	Date submitted	Date approved
Certification of permanent shutdown	September 2013	Not applicable
Security exemption – suspension of security during an emergency or severe weather	October 2013	February 2015
Request for approval of certified fuel handler training programme	October 2013	October 2014
TS amendment request – admin controls section	October 2013	December 2014
TS amendment – remove certain engineered safeguard features during fuel management	November 2013	February 2015
Cyber security milestone 8 – implementation date extension	December 2013	November 2014
Emergency plan exemption request	March 2014	December 2015
TS amendment permanently defueled (PDTS)	March 2014	October 2015
On-site insurance exemption request	April 2014	Not applicable
Off-site insurance exemption request	April 2014	Not applicable
Permanently defueled emergency plan (PDEP)	June 2014	December 2015
Vermont Yankee quality assurance programme manual	October 2014	Not applicable
Post-shutdown activity report	December 2014	Not applicable

Site-specific decommissioning cost estimate (DCE)	December 2014	Not applicable
Integrated fuel management plan (IFMP)	December 2014	October 2015
Request to cancel lines of credit	December 2014	April 2015
Request to cancel parental company agreement	December 2014	April 2015
Permanent shutdown: December 2014		
Certification of permanent removal of fuel	January 2015	Not applicable
Trust fund exemption request	January 2015	June 2015
Security plan revision	April 2015	Not available
Records retention requirement exemption	February 2015	December 2015

Decommissioning planning

Main strategies and approaches used

Plant to be place into safe storage condition until sufficient decommissioning funds are available or sale of plant currently being proposed.

Decommissioning scope, start and end point

After up to a 50-year safe storage period, the plant will be dismantled and decontaminated and the buildings demolished to a greenfield state.

Defueling and fuel logistics strategy

Spent fuel will be moved to a dry fuel storage facility by the end of 2018. No repository or off-site storage currently available for spent nuclear fuel.

Waste management strategy

Disposal site access is currently available.

Social/economic impact

Significant economic impact of community. Loss of jobs and property tax revenue.

Business strategy and financial provisions

As plant was shut down prematurely, the decommissioning fund was not fully funded. Strategy is to delay D&D until sufficient funds have accumulated through investment of the decommissioning fund. Strategy will be changed if proposed sale of plant is finalised.

Decommissioning organisation and staffing

Corporate and decommissioning site organisations and interactions

Most of the decommissioning organisation is on-site with some support from corporate organisations. Primary departments are: decommissioning project, dry fuel storage, radiation protection, oversight, finance and industrial safety.

Planning, implementation and project management approach for optimisation

Use detailed schedule and Earned Value Management System to control cost and schedule.

Experience and knowledge management methods

Retain key employees, Conduct exit interviews as long-term employees leave the site.

Preparation and training of decommissioning staff

Utilise staff with experience at other sites to mentor retained operating plant staff and/or benchmark/compare notes with other decommissioning plants.

Projects conducted during transition period

Initial site characterisation

Perform a site assessment study which is a comprehensive summary of the current environmental and radiological conditions of the site and to document the plans to terminate the plant licence.

System and building decontaminations

As of May 2015, seven structures had been dismantled at the plant site. These structures were dismantled to improve the security plan.

One interim waste storage pad has also been dismantled.

Asset management

Targeted asset recovery actions to reduce spares inventory systems that have been abandoned. Outsources asset recovery to a speciality auction firm.

Cold and dark

By May of 2015, 24 out of 50 systems had been drained and put into layup and an additional 11 were systems scheduled to be drained and put into layup by the end of 2015. Expected to complete cold and dark conditions by the end of April 2016. Unlike the activities to establish cold and dark conditions at several other plants, temporary power source will not be installed at the plant to repower the plant systems until the end of the safe storage period.

Emergency power

Install a new larger capacity diesel generator to replace the old diesel generator.

Disposition of operational waste

Disposal sites available. Waste shipped to these sites as they have been during plant operation.

Technology and technical requirements – Preparations for dismantlement projects

As most D&D will be done after 50 years, little preparations are made other than to move spent fuel to dry storage. If the proposed sale is finalised, the new licensee will perform preparatory activities.

Lessons learnt

Positive results

The decision to permanently shut down Vermont Yankee was made 16 months before the actual date of permanent shutdown. During these 16 months, many regulatory submittals were prepared and submitted to the NRC. Early submittal of these documents is expected to have significantly reduced the duration of the transition to SAFSTOR (with wet fuel storage). The schedule in the PSDAR indicates that the duration from permanent shutdown to SAFSTOR status will only take ~16 months. Further, early submittal of these documents has helped minimise the duration to implement cost saving measures (e.g. implementation of reduced emergency plan requirements).

The emergency plan exemption and the permanently defueled emergency plan were submitted to the NRC together (as two separate enclosures to a single transmittal letter). This is expected to be a best practice to help ensure that the documents are consistent with each other and to help minimise the duration of the NRC review.

Difficult challenges

State of Vermont intervention in virtually every licensing action has resulted in several Atomic Safety Licensing Boards (ASLBs) with associated costs and uncertainties. NRC staff has consistently granted exemptions in requested time frames, but ASLB proceedings may continue for up to one year after licensing action is approved by staff.

Annex B. Contracting methods

Decommissioning activities are often contracted to the supply chain. Depending on the industrial strategy, the owner/licensee might choose one of the following contracting models:

- fixed-price (lump sum) contracts;
- time and material contract;
- cost-plus-fixed fee contracts;
- target cost-plus-incentive-fee;
- target cost-plus-incentive-fee with shared savings.

The IAEA report "Financial Aspects of Decommissioning" (IAEA 2005) provides descriptions of these contracting models. For decommissioning fixed-price (lump sum) contracts is one of the preferred options in some NEA member country, such as France.

This fixed-price (lump sum) model of contracting assumes that the contracts should be based on a set of essentially functional specifications, defining the expected functional requirements in terms of safety, security, radiation protection, environment, waste, process, performance etc., to allow the supplier to have enough initiative margin. In this arrangement, the reference scenario is therefore not a requirement of the specification. It is provided in the call for tender file as a possible scenario which is judged by the contracting authority as meeting the functional requirements specifications. The candidates have an opportunity to make an offer based on this scenario and / or an offer based on a variant or alternative scenario they consider also meeting the functional requirements specifications. The technical assessment of bids by the contracting authority is on the fulfilment of functional requirements and not the judgement of deviations from the reference solution.

During the contract, the monitoring by the contracting authority only concerns the respects of the requirements of the specifications and on the regulatory requirements, not on the details of implementation, which remains the full responsibility of supplier.

Although this model of contracting is the preferred solution for dismantling operations, the choice should be made only after ensuring:

- That there available an industrial panel that agrees to be involved. In particular, the preparation of an offer in such an arrangement requires a strong investment studies. The simplicity and reliability of input data actually could transfer the majority of risks to the provider. Complex input data and unreliable (type calculated radiological inventories) leave in fact an important part of risk on the project owner which, if it becomes dominant, makes this type of contract less interesting.
- Compatibility with the elements mentioned in the public inquiry.
- Consistency with the regulatory requirements.

Depending on the size or the nature of the operation to be performed, several variations of this contract model can be implemented at the early stage of the buying process.

This type of contract has some disadvantages, such as:

- The major drawback is to transfer a maximum of risks to contractor, which in the principle of fixed price, requires them to make provision in their offer, more or less, to cover these risks and, ultimately leads to potential claims.
- It requires a strong investment in design studies for call tender submission, and could lead the owner/licensee to pay the offers (if they are technically acceptable).
- Alliances are necessary to cover all specialties with the risk to put in minority small firms towards large groups.

Difficulties for assessing the target price from a functional specification and subject to claims from the contractor in most of the cases.

Reference

IAEA (2005), *Financial Aspects of Decommissioning*, IAEA-TECDOC-1476, IAEA, Vienna.

Annex C. Comparison of requirements for the regulatory framework and authorisation process for decommissioning in various NEA member countries

During its activities, the Task Group on Preparing for Decommissioning during Operation and after Final Shutdown (TGPFD) has carried out a survey among its members to collect information on national requirements, preparatory activities and responsibilities during transition from operation to decommissioning. It was determined that the requirements for maintaining an organisation and manage the changes are contained in the specific state regulatory regime (framework).

The responses from Canada, France, Germany, Japan, Korea, Spain, Sweden, Switzerland, the United Kingdom and the United States are provided in this annex in a comparative way starting with a summary of the conclusions and detail responses afterward.

C1. Summary of conclusions

Regulatory framework for decommissioning

All NEA participating countries reported to have an established regulatory framework for decommissioning.

Requirements for decommissioning authorisation

In all NEA member countries a licence to decommission or some kind of approval is required prior to decommissioning.

In most countries, more than one regulatory authority is responsible for the approval of decommissioning. The regulatory body and environmental authorities have a key role while the regional, local authorities and other stakeholders might be involved at different stages of approval process.

Preparatory activities under operation licence

Most of participating countries allow preparatory activities, reducing the hazards and preparing the facility for transition to decommissioning, to be conducted prior to authorising decommissioning. In most countries, those activities are performed under the operation licence and procedures and include: unloading of fuel assemblies, managing radioactive waste from operation, radiological characterisation, decontamination of the facility and systems.

Responsibility for decommissioning

In most participating countries, the operator is responsible for conducting decommissioning. In Spain, the responsibility and the licence is transferred to a decommissioning organisation. In United States and Sweden, the responsibility could be transferred to a third, contracting party.

Licence documentation submitted for decommissioning

In most participating countries, similar information is required by the regulatory authorities in support of application for decommissioning. The submitted documentation may vary by title or structure but should provide information on decommissioning strategy, schedule, scope, project description and risk analysis for the decommissioning project.

Decommissioning plan and safety assessment report are the key documents required prior to decommissioning.

Additional information in relation to organisation, radiation protection, radiological characterisation, decommissioning technical specifications, material and waste management, emergency measurements, cost estimation, final survey plan and public information is also commonly required.

Timeframes relating to decommissioning authorisation process

No particular time frame has been established for transition to decommissioning. In most countries "the transition period" is considered from cessation of operation to obtaining an authorisation to decommission.

Most participating countries, with the exception of France, reported not to have strictly established timelines for documentation submissions and authorisation of decommissioning. The timelines are established on a case-by-case basis and triggered mainly by achieving a milestone activity rather than specifying the time. The decision to shut down and shutting down the facility defines most of the timelines. Some countries, e.g. France and South Korea, are more time prescriptive than another.

Initial decommissioning plan (IDP)

In all participating countries, with the exception of United States, an initial decommissioning plan (IDP) is required. The scope and the requirements for maintaining and updating the IDP vary from country to country. In most countries the IDP should be maintained through the life cycle of the facility.

C.2. Information from comparison of the regulatory framework and authorisation process for decommissioning

Regulatory framework for decommissioning

All countries have reported to have an established regulatory framework for decommissioning.

Requirement of a decommissioning authorisation

Canada

A decommissioning licence is required.

France

A decommissioning licence is required.

Germany

A decommissioning licence is required.

Japan

No decommissioning licence is required. But a decommissioning plan has to be approved and the confirmation of decommissioning completion is required at the final stage of decommissioning.

Korea

No decommissioning licence is required, but a decommissioning plan has to be approved before the start of decommissioning. Decommissioning is under the effective operating licence.

Spain

A decommissioning licence is required.

Sweden

A licence according to the Environmental Code is required. A specific decommissioning licence is not required according to the Act on Nuclear Activities, but approval of certain documents by the Swedish Radiation Safety Authority (SSM) is needed.

Switzerland

A decommissioning licence is required as the operation licence expires.

United Kingdom

No decommissioning licence required.

United States

No specific decommissioning licence is required. Decommissioning is performed under the plant operating licence (more information can be found below in the section "Decommissioning activities under the operating licence"). The NRC is working on a revision to these regulations.

In the United States, some decommissioning activities can begin without regulatory approval as long as the SSCs involved do not involve documents for which changes require regulator's approval, such as technical specifications for nuclear safety-related systems. In these cases the basis for the downgrading of the nuclear safety-related system would need to be supported by documentation and the changes approved by the regulator before the system could be declared available for dismantlement (i.e. abandoned).

Licence documentation submitted for decommissioning

Canada

Application for a decommissioning licence including detailed decommissioning plan supported by documentation covering 14 Safety and Control Areas (SCA):

- management system, human performance management, Operating performance;
- safety analysis, physical design;
- environmental protection;
- radiation protection;
- conventional health and safety;

- fitness for service, packaging and transport, waste management;
- security, safeguards and non-proliferation;
- emergency management and fire protection.

Additional areas as:

- environmental assessment;
- CNSC consultation – Aboriginal, CNSC consultation – other;
- cost recovery, Financial guarantees;
- improvement plans and significant future activities;
- licensee public information programme;
- nuclear liability insurance is also assessed.

France

The dismantling licence decree requests a documentation to be submitted that includes:

- description of the initial status of the plan before dismantling operations starts;
- update of the dismantling plan (milestones, hold points if any, structures and soils decontamination strategy, future use of the site);
- environmental impact study including waste management policy;
- plant safety analysis report (PSAR);
- risks analysis;
- non-technical summary for the purpose of public enquiry;
- notice describing the operator financial capacities.

Germany

A letter of application for a decommissioning licence needs to be submitted along with the following documents:

- safety report;
- supplementary plans, drawings and descriptions of the facility and the planned decommissioning techniques and procedures;
- report on physical protection;
- reliability and technical qualification of plant personnel;
- know-how and reliability of other personnel;
- list of measures relevant for safety;
- financial security measures;
- radioactive residues;
- overriding public interests, environmental impact;
- documents for environmental impact assessment;
- brief description;
- list of documents submitted;

- adaptation of operating manual and testing manual;
- details of licensing decisions, conditions and permits to be suspended or modified;
- documents required by building regulations;
- documents required by the Federal Immission Control Act;
- documents relating to water rights.

Japan

After shutdown, the decommissioning plan has to be submitted that includes:

- facility to be dismantled;
- dismantling method;
- management or transfer of nuclear fuel materials;
- removal of contamination by nuclear fuel materials;
- disposal of nuclear fuel materials or materials contaminated by nuclear fuel materials;
- decommissioning schedule;
- radiation control, safety assessment and systems;
- final stage of decommissioning:

At a final stage of decommissioning, a document has to be submitted describing status implementation of:

- dismantling;
- transfer of nuclear fuel material;
- removal of contamination with nuclear materials;
- management of materials contaminated with nuclear fuel material and the final distribution of contamination with nuclear materials.

Korea

- construction permit and operating licence stage: IDP;
- during the operation period: IDP shall be updated every ten years;
- for decommissioning approval:
  - final decommissioning plan (FDP);
  - quality assurance programme (QAP) for decommissioning;
  - public consultation records.

Spain

Letter of application decommissioning licence including the decommissioning plan supported by:

- safety analysis;
- operating regulations;
- technical specifications applicable during the dismantling phase;

- quality assurance manual;
- radiological protection manual;
- on-site emergency plan;
- management plan for radioactive waste and spent fuel;
- site restoration plan;
- economic study of the dismantling process and its associated financial provisions;
- plan for the control of clearable materials;
- physical protection plan;
- environmental analysis.

Sweden

- Application to the Land and Environmental Court with environmental impact assessment.
- To the Radiation Safety Authority:
  - Analysis and assessment of how safety is to be maintained during the time remaining until closure, changes in organisation during the closure period and personnel requirements during decommissioning.
  - Updated decommissioning plan with description of which parts of the facility and which equipment will be required during decommissioning as well as which preparatory actions will need to be undertaken before dismantling and demolition can commence.
  - Updated safety analysis report in accordance with the revised decommissioning plan.

Switzerland

- decommissioning project;
- phases and timetable for decommissioning work, decommissioning variants;
- individual step for decommissioning work;
- updated safety analysis report;
- procedure for separating radioactive and non-radioactive waste and radioactive waste management;
- radiological protection measures;
- security measures;
- accident analysis and emergency measures;
- human and organisational factors;
- management system;
- environmental impact report;
- total cost and securing of the financing.

United Kingdom

Decommissioning plan and safety case are required to meet with the nuclear site licence conditions.

United States

No decommissioning plan, the post-shutdown decommissioning activities report (PSDAR) and licence termination plan have to be submitted.

Other major documents submitted are listed below under the section "Requirements for initial decommissioning plan and its orientation".

Timeframes relating to decommissioning authorisation process

Canada

No specific timeline is established for submission of decommissioning licence application. Recommended to start discussion with CNSC as early as possible.

France

- Operator informs the Ministry in charge of the Nuclear Safety (currently Sustainable Development and Energy Ministry) of the date of final shutdown – Two years before final shutdown.
- Within two years after the letter announcing final shutdown, operator must submit the request for dismantling licence decree.
- Within three years after issuing the request for dismantling licence decree the Ministry in charge of the nuclear safety must have completed the review of the dismantling plan.
- The French Nuclear Safety Authority would accept a delay of 6 to 12 months to put in force the dismantling licence decree.
- Conclusion: Transition period duration would be at least three to four years.

Note: it might be possible for the operator to ask an extension of the two years delay for submitting the request for dismantling licence decree (this extension is anyway limited to two years).

Germany

Not established. Shutdown of nuclear power plants required by political decision.

Japan

After permanent shutdown and prior to start of decommissioning work. Plan is to be revised as progress is made. Operational safety programme can also be changed as progress is made.

Korea

- Construction permit and operating licence stage: IDP shall be submitted to the regulatory body as one of application documents.
- During the operation period: IDP shall be updated every ten years.
- Approval of decommissioning: in case of NPP, the licensee shall apply for the approval of decommissioning within five years after the permanent shutdown.

Spain

Case by case, but is planned to establish two years after shutdown.

Sweden

- To Environmental Court: no established time but licence is required prior to decommissioning.
- To Radiation Safety Authority:
  - First rapport on changes in organisation shall be submitted without delay after a decision on final shutdown.
  - Within a year of final shutdown the updated decommissioning plan and safety analysis report shall be submitted.
  - Rapport according to Euratom Art. 37 shall be submitted at least one year previous dismantling.
  - A further developed decommissioning plan and updated safety analysis report shall be submitted before dismantling may be initiated. Where the decommissioning plan is divided up into a series of smaller work sequences or partial projects, a review of the planned measures during each sequence shall be communicated before these activities commence.

Switzerland

Case by case, but at the latest two years after final shutdown.

United Kingdom

The final decommissioning plan should be available before decommissioning starts. The safety case needs to be submitted before the start of decommissioning operations.

United States

- Licensee shall within 30 days after the decision to permanently shut down the plant, submit to the NRC a written certification of completing the defueling and the permanent cessation of operation of the reactor.
- PSDAR must be submitted within two years of Certification of Permanent Closure.
- Licence termination plan must be submitted at least two years before licence termination.
- Other submittals are listed below in the section “Requirements for initial decommissioning plan and its orientation”.

Decommissioning activities under the operating licence

Canada

Some preparatory activities are in place as long as they do not deviate from the operational licence conditions and the safety case. For example removal of the fuel, draining the systems, transfer of waste, preliminary surveys could be allowed under the operational licence since many of those activities are routinely performed during the operation of the facility and the necessary safety and procedure documents are in place.

France

No dismantling activity is authorised before the dismantling licence decree is put in force, but preparatory activities aiming to reduce the risks or contributing to the preparation of the dismantling phase allowed such as:

- fuel removal from site;
- waste characterisation;
- nuclear circuits decontamination;
- shut down of unnecessary systems;
- dismantling of equipment in turbine hall;
- preparation of workshop for waste treatment (but forbidden to put them in operation);
- hazardous fluids or materials removal from site;
- only very few equipment could be dismantled.

Most of these operations will be subject to the French Nuclear Safety Authority information or authorisation.

Germany

Only preparatory activities, which are covered by the operating licence:

- Unloading of fuel assemblies, handling of radioactive substances and disposal of radioactive waste from the operational phase, replacement of systems and components, decontamination of the facility and systems.
- Radiological characterisation is necessary for the decommissioning licence application and thus allowed including sampling.

Japan

Removal of spent fuel from reactor core is performed during operational phase.

No decommissioning work can be performed until the decommissioning plan is approved.

Korea

Yes.

Spain

- no decommissioning activities;
- preparatory activities:
  - spent fuel removal;
  - radiological characterisation, preparation of decommissioning plan and licensing;
  - documentation;
  - conditioning of radioactive waste from the operational phase;
  - decontamination of system.

Sweden

No decommissioning activities.

Preparatory works covered by the operating license (unloading of fuel assemblies, handling of radioactive substances and disposal of radioactive waste from the operational phase, replacement of systems and components, decontamination of the facility and systems, etc.).

Switzerland

Only preparatory activities:

- Measures to transfer the facility into transition phase (unloading of fuel assemblies, handling of radioactive substances and disposal of radioactive waste arising from the operation, radiological characterisation, decontamination of the facility and systems).
- Some particular preparatory works on extra application (installation of decommissioning and supply facilities, unload turbine hall, etc.).

United Kingdom

No. Decommissioning is regulated via the nuclear site licence conditions, which cover all stages of the life cycle. Under license conditions the licensee must seek agreement from the safety regulator to start decommissioning. Further agreements may be required for later decommissioning stages. The operator also needs to submit an environmental impact assessment to the safety regulators (Office for Nuclear Regulation) which issues consent. The safety regulators ask for comments from various stakeholders including the environmental regulators.

United States

Yes. All decommissioning performed under the operational licence. If storing spent fuel on-site, the operational licence can be amended to include only the ISFSI and the remainder of the site is released from the licence or the ISFSI can be licensed under a new NRC 10 CFR Part 72 licence and the operational licence terminated.

Requirements for initial decommissioning plan and its orientation

Canada

Yes. Planning for decommissioning and financial guarantees are required throughout the life cycle of the facility for site, construction, operation and decommissioning licences.

France

Yes. Together with the letter informing the Ministry in charge of the Nuclear Safety that the plant will be definitively shut down, the operator sends an update of the dismantling plan. This update describes:

- the operations that will be conducted before the dismantling decree is put in force;
- the equipment that will be necessary for the dismantling activities (existing or new equipment);
- anticipated waste routes;
- operator organisation during transition period and dismantling period.

Germany

Yes. Initial plan demonstrating the feasibility of decommissioning in accordance with the radiation protection requirements and periodic review generally specified in operating licence.

Japan

Yes. Plan to be revised and resubmitted for review as decommissioning progress is made.

Application for confirmation of decontamination completion is to be submitted for review and approval prior to completion of decommissioning.

Korea

Yes. IDP shall be required at the construction permit and operating licence application stage of NPP. And IDP shall be updated every ten years during the operating period.

Spain

Yes, but only for forecast purposes:

- construction licence: technological, cost estimation and funding aspects of decommissioning;
- operation licence: waste management, cost estimation and funding aspects of decommissioning (financial guarantees required).

Sweden

Yes.

- a preliminary plan for the future decommissioning of the facility is to be compiled before construction of a facility;
- safety and radiation protection at the time of decommissioning shall be taken into account during the construction of a facility and before changes are made in an existing facility;
- the preliminary plan shall be supplemented and kept up to date for the duration of the facility's operation and shall be reported to the regulatory authority every ten years;
- during the operation of a facility, observations and events that have significance for planning and execution of decommissioning shall be documented on an ongoing basis.

The information to be contained in the decommissioning plan includes requirements relating to documentation of the facility, prerequisites for planning and the decommissioning activity itself.

Switzerland

Yes.

- decommissioning concept (initial plan) for general licence;
- decommissioning plan for construction licence (NPP) or a project for the monitoring period and a plan for the closure of the installation (other facilities);
- updating of plan or project concerning decommissioning and closure every ten years and periodic review.

- content:
  - choice and motivation of decommissioning variant;
  - measures during operation in order to facilitate subsequent dismantling;
  - safety systems and installation components that will still be needed or adapted;
  - additional systems required for dismantling and waste management;
  - safety assessment;
  - quantity and schedule of expected radioactive waste and cleared materials;
  - transport and storage casks for the removal of fuel elements after shutdown;
  - interactions of systems and organisation with other nuclear installations in the same site;
  - report on evaluation of experience gained from current decommissioning projects of comparable nuclear installations in Switzerland and abroad.

United Kingdom

Yes. An initial decommissioning plan is required at the planning and design stage under licence condition 35. This demonstrates that decommissioning can be achieved, informs the design process, and is used as the basis of initial waste and cost estimates.

For new nuclear power stations, a funded decommissioning programme is required to be submitted and approved before construction starts.

United States

No, but there are other regulatory submittals.

For information:

- PSDAR – high-level description decommissioning.

Revised major documents for NRC approval:

- safety analysis report – new plant design basis;
- technical specifications;
- emergency plan;
- security plan;
- spent fuel management plan;
- licence termination plan – basis for radiological release of the site and funding adequacy.

Dealing with different competent authorities involved in the decommissioning authorisation process

Canada

Yes. Although the nuclear sector is subject to federal jurisdiction through the Nuclear Safety and Control Act, the CNSC utilises a harmonised or joint review approach with other federal, provincial or territorial departments in such areas as health, environment, transport and labour. The CNSC expects nuclear facilities to comply with all applicable federal and provincial regulations.

As a lead agency, the CNSC invites other federal and provincial regulatory agencies to participate in the licensing process when their areas of responsibility could impact the proposed nuclear facility. Those that choose to participate become members of a site-specific joint regulatory group.

France

Yes.

Germany

Yes.

Japan

No, only Nuclear Regulation Authority (NRA).

Korea

Yes. NSSC (Nuclear Safety and Security Commission, governmental organisation) and KINS (Korea Institute of Nuclear Safety, regulatory body).

Considering opinion of local government and local public citizen.

Spain

Yes. Regulatory body (CSN) with ministries involved (industry, environment and interior).

Regional and local authorities.

Sweden

Yes. Mainly the Land and Environmental Court and Radiation Safety Authority.

Switzerland

Yes. Regulatory body (ENSI) with/and departments (DETEC, granting authority) and cantons (federal states) involved (environmental impact assessment).

United Kingdom

Yes. The Office for Nuclear Regulation is responsible for the regulation of nuclear safety, security and transport on nuclear licensed sites. The environmental regulators are responsible for regulating radioactive waste discharges during operations and decommissioning.

United States

Yes. NRC is lead regulator for radiological, but state authorities can be more restrictive.

The US Environmental Protection Agency or state agency oversees non-radiological site release.

Operator is the decommissioning responsible

Canada

Yes.

France

Yes.

Germany

Yes.

Japan

Yes.

Korea

Yes.

Spain

No. Transfer of licence to Enresa.

Sweden

Yes, the licence holder is the responsible, but in principle it is possible to transfer the licence to another company or organisation.

Switzerland

Yes

United Kingdom

The implementation of decommissioning is the responsibility of the licensee. UK civil public sector nuclear sites are strategically managed by the Nuclear Decommissioning Authority (NDA).

United States

Normally yes, but licence can be transferred to another company such as at Zion plant where the operating licence has been transferred to ZionSolutions. NRC is responsible for oversight and inspection of the decommissioning activities.

Annex D. Systematic approach to training (SAT)

During operations, the nuclear facilities developed and implemented systematic approach to training (SAT) based (SAT-based) training programmes. If a new organisation will decommission the nuclear facility, then the new organisation will develop and implement the SAT process utilising the job and task analysis processes associated with the analysis functions, to identify all the tasks that must be perform by each work group or job family and to identify knowledge, skills and safety-related attributes that the workers must have to perform each task effectively.

The training process during the transition to decommissioning should have a systematic approach with similar phases as for the operation of the nuclear facility. However, the process needs to adapt to the changes. The training process shall be synchronised with the new configuration of the facility. In general, the external contractors bring new skills and competencies. The training process is applicable to all, including contractors.

If the same organisation that operated the nuclear facility will perform the decommissioning, some regular training programmes for tasks that have not been changed (e.g. conventional health and safety) will be the same. In the first phase, the competence of staff of the operating facility is used or the competence is acquired by professional conversion. If the operators are already qualified for routine operations that were performed during operation and during the shutdown and after shutdown, then no additional training and qualification is performed. Some activities require additional skills and new training programmes. Personnel are necessary to develop multi-skilling if it is necessary. As new technologies are developed to produce less waste and safer environment, new skills are necessary to be planned and implemented.

The importance of training during the transition to decommissioning is highlighted in different NEA, IAEA and EC documents (IAEA, 2008, 2004, 2000; EC, 2008). The qualification of the decommissioning/dismantling staff is required by the state members and the NEA member countries' regulatory framework has the specific requirements.

Training process during transition

All training systems, that base on a systematic approach, features a loop of the interdependent functions of analysis, design, development, implementation and evaluation. It is this cyclic process that enables training to meet extant operational requirements, but also to react quickly to changes in those requirements. These changes in requirements may result from ongoing engineering and/or procedural changes or from a change in the state of the facility.

Each phase of training base should be documented and implemented during the transition to decommission. The process is applicable in a graded manner, commensurate with risk. When a few worker categories are in place, a simplified training is developed and implemented. The radiological risk associated with the activities always needs to be assessed.

The analysis phase is the foundation of any training course or training programme and includes inputs from operational and decommissioning staff, users including contractors, subject matter experts and training development experts. The analysis phase is the key step for the transition phase for decommissioning and dismantling and contains the following steps:

- Training needs analysis. The analysis is used to assess the skills and knowledge gaps and transfer of knowledge created by the changes in the configuration of nuclear facilities, operational changes after shutdown (e.g. transfer of activities from operation to maintenance and surveillance), revised operational procedures, issuing new procedures for decommissioning and dismantling, research and development activities and new regulatory requirements. The knowledge is retained during the transition to decommissioning (e.g. surveillance and maintenance).
- During job and task analysis phase are identified all the tasks involved in the new state of the nuclear facility and transition to decommissioning and dismantling, including performing some decommissioning work, accident conditions and emergency. The jobs with radiological risks always shall be identified. If the future planned activities will be performed by a contractor, then the analysis should take in consideration that the contractors should have the necessary operational skills including the operation into the radiological environment. In practice, a list with all the tasks that need to be completed is issued. The list is a controlled document that should be updated with sufficient frequency to ensure the process effectiveness. Task difficulty, importance and frequency are considered to determine which tasks need to be part of training and to determine the initial and continuing training content. A task analysis is conducted to determine the method of task performance and associated knowledge, skills and safety attributes. The analysis includes the frequency of the tasks to be performed. The outputs of this phase include the identification of job requirements, performance expectations and tasks required the training and selection of the appropriate training.
- Learning objectives should be defined. Terminal learning objectives are statements of the tasks that the workers must be able to demonstrate after completing the training.
- During target audience analyses it is determined the number and categories of workers to be trained, and where possible, the characteristics of the individuals who will receive training.

During the Design phase, the training is organised into discrete topics and needs to ensure a logical sequence. The knowledge, skills and safety-related attributes lead to documentation of the enabling training objectives. The appropriate training delivery methods (classroom, on-the-job, computer base) are developed. The organisation will determine the method of assessment (i.e. written, practical) and the training plan.

For development phase, the lesson plans for each topic are created. The existing training material is reviewed to determine suitability. Training materials are developed. The training could include generic training (radiation protection, work permit authorisation, confine space entry, emergency first aid, fall protection), process specific training (e.g. reactivity determination, use of tools underwater) and project specific training (e.g. configure the facility for core removal, irradiated core removal, response to emergencies, hazard assessment). Feedback forms are created once training is complete.

During the implementation phase, qualified instructors are assigned and training is delivered in according to the plans. The training is continually assessed and the assessments are reviewed.

In the evaluation phase feedback is gathered from trainees and supervisors, regarding training and worker performance. Any change should be regularly inputted into analysis phase.

It can take a long period of training and experience for some specialised staff (e.g. radiation protection) to develop competency in carrying out their duties. Therefore, the senior management of the operating nuclear facility or the organisation in charge for decommissioning must plan ahead and ensure that any changes in staffing levels through downsizing or hiring will address future staffing needs. When reductions in staff are considered, the risk in delaying, reducing, reorganising or eliminating tasks or projects is assessed and the management should consider options for replacing staff with special expertise. The IAEA (2008) highlighted that longer the time between plant shutdown and start of decommissioning “there is a greater need for un active policy of retention of the knowledge and training, in order to capture the experience and knowledge of the outgoing personnel”.

During the transfer to a new model of organisation for decommissioning, the owner organisation should take advantage of the key previous organisation representatives, if available, to provide support to share transfer including the training programme. During the transition to the decommissioning, the training programmes enhanced with the participation of specialised personnel from the operation of the facility. Operating personnel who will continue working during the decommissioning and dismantling must be also trained. In general, during the decommissioning there is a mixture of experienced personnel having operating experience and knowledge and personnel with decommissioning experience and knowledge. The training programme should be adapted to the field situation.

Training of all staff in all aspects of decommissioning and waste management should ensure the capability of staff in addressing an unexpected event is known and the personnel are able to deal with it. The training programme should aim to respond to unexpected events. If an unexpected event happened, and the event was caused by inadequate training, the corrective action should include the training programme (IAEA, 2016).

Experience in the state members related to training

In Canada, during the recent shutdown of Hydro Quebec CANDU Nuclear Power Plant Gentilly-2 (G2), the licensee’s training programme and associated procedures were revised to reflect the new state of the plant. The training programme meets the regulatory requirements. Some activities necessary to put the plant in a safe storage state, such as resins transfer, required development of specific training. This was completed with the help from qualified and experienced personnel from the engineering department in addition to the operation department personnel. Pre-job briefings were used as a training tool for other activities for which the workers were already qualified. Furthermore, G2 kept ex-qualified operators in the new permanent organisational structure for the operation of the remaining active systems, such as heating, ventilation or electrical distribution and for the waste management. These staff will get support from the five maintenance units on-site (civil, electric, mechanic, chemistry, and instrumentation) for surveillance activities of the systems. Training was developed and provided to the maintenance personnel and included three phases: classroom training, field training which was familiarisation training in the field and was performed immediately following the classroom training, and finally, co-piloting training with ex-qualified operators which consisted of hands-on training in the field. Ex-G2 subject matter experts, including ex-qualified operators with experience in training and evaluation of operating personnel, were involved in the analysis, design, development and delivery of training for the maintenance personnel. Training programme for waste management personnel and for radiation protection were also revised or developed.

In some countries (i.e. United Kingdom), specific training programmes were established to provide a career in the field of decommissioning. A brief description is stated in the IAEA report *Decommissioning of Nuclear Facilities: Training and Human Resources*

Considerations (IAEA, 2008). Kockerols et al. (2016) also provides a general assessment of the training in the decommissioning.

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Preparing for Decommissioning During Operation and After Final Shutdown

The transition from an operating nuclear facility to the decommissioning phase is critical in the life cycle of every facility. A number of organisational and technical modifications are needed in order for the facility to meet new objectives and requirements, and a certain number of activities must be initiated to support the transition and preparation for the dismantling of the facility. Thorough preparation and planning is key for the success of global decommissioning and dismantling projects, both to minimise delays and undue costs and to ensure a safe and efficient decommissioning process.

The aim of this report is to inform regulatory bodies, policy makers and planners about the relevant aspects and activities that should begin during the last years of operation and following the end of operation. Compiling lessons learnt from experiences and good practices in NEA member countries, the report supports the further optimisation of transition strategies, activities and measures that will ensure adequate preparation for decommissioning and dismantling.

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