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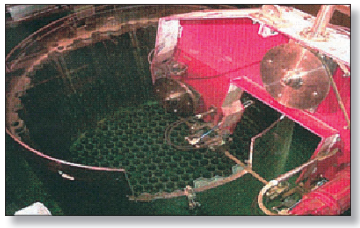
International Structure for Decommissioning Costing (ISDC) of Nuclear Installations



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International Structure for Decommissioning Costing (ISDC) of Nuclear Installations

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NUCLEAR ENERGY AGENCY
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Cover photos: Dismantling activities at the Greifswald nuclear power plant, Germany (EWN).

Foreword

Nuclear Decommissioning: A Proposed Standardised List of Items for Costing Purposes, colloquially known as "The Yellow Book", was published in 1999 as a joint initiative of the OECD Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA) and the European Commission (EC). The intent of the original report was to provide a uniform list of cost items for decommissioning projects, with the aim of facilitating communication, promoting uniformity and avoiding inconsistency in cost evaluations for decommissioning projects.

One decade later, in 2009, the three sponsoring organisations decided to update the Yellow Book and undertook, as a preliminary step, an evaluation of users' experience in the use of the standardised cost structure. The overall project was co-ordinated by the NEA Decommissioning Cost Estimation Group (DCEG), in which the IAEA and the Directorate-General for Energy (DG-ENER) of the European Commission participated.

The review concluded that the cost structure proposed in the Yellow Book was being used in several countries – either directly or by mapping the cost evaluation onto this structure for purposes of comparison – but that its use was not universal, for example because national reporting requirements called for a different aggregation of costs. Respondents identified a number of ambiguities in the definition of certain cost items and called for greater coherence at different hierarchical levels of the structure. The survey also showed a strong need to have an associated Users' Manual to provide guidance on applying the standardised cost structure to different types of cost estimate and thereby to promote greater uniformity in estimations.

The two-year project leading to the production of this report was a co-operative effort among the three sponsoring organisations. It comprised three main elements: a) an overview of decommissioning costing managed by the NEA; b) an update of the cost structure managed by the IAEA; and c) the preparation of a Users' Manual managed by DG-ENER. These three outputs were subsequently integrated into this report, which supersedes the 1999 edition. In order to avoid any confusion with the earlier cost structure, the standardised structure described in this report will be known as the International Structure for Decommissioning Costing (ISDC).

Acknowledgements

The sponsoring organisations wish to express their particular gratitude to Kurt Lauridsen and Vladimir Daniška for their contributions to the drafting of this report. Mr. Daniška's involvement in this activity was supported by the Slovak Research and Development Agency through grant No. APVV-0761-07.

The responsible officers for this publication were Thomas Kirchner (EC), Michele Laraia (IAEA) and Patrick O'Sullivan (OECD/NEA and IAEA[1]).

1. From December 2010.

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Executive summary

Decommissioning cost estimates may serve a variety of purposes, depending on the stage in the project lifetime at which the estimate is made, and the audience for the estimate varies accordingly. In the case of estimates undertaken at the conceptual design stage of a project, the main purpose is to enable designers and client organisations to establish overall project costs. When the project planning has advanced to the point that licensing approvals are being sought, the relevant authorities and affected stakeholders will need to be satisfied that arrangements will be put in place to ensure that the necessary funds to cover decommissioning costs will be available when needed, even in the event of a premature shutdown of the nuclear facility. At the end of the facility's period of operation, the cost estimate provides the basis for the detailed planning of the dismantling and site clean-up operations.

It has long been recognised that there is a considerable variety in the format, content and practice of cost estimates, often due to different national requirements about which activities should be included within the decommissioning cost estimate or to different assumptions about the time frame for decommissioning or about the final status of the site on which the facility is located. These differences make the process of reviewing estimates more complicated and result in a lack of transparency, i.e. it may be assumed that confidence in the veracity of estimates would be improved if it were easier to compare the results with other estimates for similar facilities.

To address the above issues, the "Yellow Book",[2] was published in 1999 as a joint initiative of the OECD Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA) and the European Commission (EC). A decade later, in 2009, the three sponsoring organisations decided to update the Yellow Book and established a joint two-year project, led by the NEA Decommissioning Cost Estimation Group, which began by analysing user experiences. This analysis found that the proposed standardised cost structure has been adopted by several countries, either being used directly for the production of cost estimates or for mapping national estimates onto a common structure for purposes of comparison. It also concluded that more detailed advice should be provided on the use of the standardised structure and, in particular, on the definition of specific cost items, to avoid ambiguity.

The revised cost structure, to be known as the International Structure for Decommissioning Costing (ISDC), is presented herein. It is intended that all costs within the planned scope of a decommissioning project may be reflected in the ISDC, which may also be used as a point of departure for cost calculations relating to risks outside the project scope. The report provides general guidance on developing a cost estimate for decommissioning a nuclear facility, including detailed advice on using the standardised cost structure, with the aim of promoting greater harmonisation.

The new cost structure incorporates the following features:

- redefinition and/or regrouping of the items in order to follow more directly the sequence of decommissioning activities, reflecting the main phases in the

2. OECD/NEA, IAEA, EC, *A Proposed Standardised List of Items for Costing Purposes in the Decommissioning of Nuclear Installations, Interim Technical Document*, OECD/NEA, Paris (1999).

decommissioning process and the basic decommissioning strategies as defined by the IAEA;

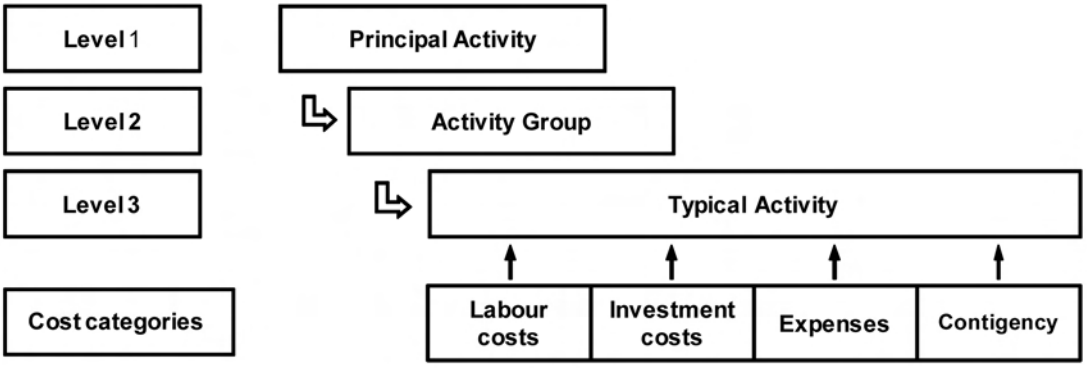
- providing a general cost structure suitable for use for all types of nuclear installations, i.e. including fuel cycle facilities, laboratories and other facilities (as well as nuclear power plants); and
- implementing the latest IAEA classification of radioactive waste;[3] reflecting the main types of activities related to waste management such as characterisation, processing, storage, disposal and transport; and considering separately hazardous and conventional waste.

The three sponsoring organisations consider that greater standardisation of the format and content of decommissioning cost estimates is an important goal, providing greater transparency to the decommissioning process and helping to build regulator and stakeholder confidence in the adequacy of funding provisions.

The International Structure for Decommissioning Costing (ISDC)

The standard decommissioning activities identified in the ISDC are presented in a hierarchical structure, with the first and second levels being aggregations of the basic activities identified on the third level. The cost associated with each activity may be sub-divided according to four cost categories (see below).

Hierarchical structure of the ISDC



At the highest level, Level 1, 11 Principal Activities are identified:

01 Pre-decommissioning actions;

02 Facility shutdown activities;

03 Additional activities for safe enclosure or entombment;

04 Dismantling activities within the controlled area;

05 Waste processing, storage and disposal;

06 Site infrastructure and operation;

07 Conventional dismantling, demolition and site restoration;

08 Project management, engineering and support;

2. IAEA, *Classification of Radioactive Waste, General Safety Guide, Safety Standards Series No. GSG-1*, ISSN 1020–525X, No. GSG-1, STI/PUB/1419, ISBN 978–92–0–109209–0, IAEA, Vienna (2009).

09 Research and development;

10 Fuel and nuclear material;

11 Miscellaneous expenditures.

Activities at Level 2 represent a sub-division of the Level 1 activities, e.g. "Dismantling activities within the controlled area" (Principal Activity 4) is divided according to several major steps including: pre-dismantling decontamination; removal of materials requiring specific procedures; dismantling of major process systems, structures and components; and dismantling of other systems and components. "Waste processing, storage and disposal" (Principal Activity 5) is divided according to different waste types, such as high-level waste and intermediate-level waste, and differentiates between management of legacy and decommissioning waste as distinct Level 2 activities.

Activities at Level 3 provide a further sub-division of activities, e.g. pre-dismantling decontamination is divided according to drainage of remaining systems; removal of sludge; decontamination of systems; and decontamination of building surfaces. Management of low-level waste from decommissioning is divided according to characterisation; processing; final conditioning; storage; transport; disposal; and procurement of containers. Level 3 activities represent the basic building blocks for developing the overall cost estimate, the corollary being that, in order to convert estimates produced according to other cost structures, the cost estimator needs to establish first a correspondence with the Level 3 activities.

Cost estimators may add additional hierarchical levels to the cost structure, e.g. in order to distinguish costs relating to specific parts of the plant or to specific systems, or in order to distinguish costs according to specific time periods of a decommissioning project.

Cost categories

Four cost groups are defined at each level as:

- labour costs – payments to employees, payments to social security and health insurance according to national legislation and overheads;
- capital/equipment/material costs;
- expenses – consumables, spare parts, taxes etc.; and
- contingencies – a specific provision for unforeseeable elements of costs within the defined project scope.

Presentation platform for the standardised listing of costs

An important objective of the ISDC, as for the original Yellow Book, is to promote greater harmonisation in the reporting of decommissioning costs, based on a standardised reporting structure. The presentation format is based on a matrix which reflects the hierarchical cost structure (see below).

Cost data are introduced into the matrix at the third level, with data at Levels 1 and 2 being aggregated data from lower levels. Users may, at their own discretion, extend the matrix by adding additional columns that include other data such as manpower, exposure and waste data. The total cost of each activity is the sum of four basic cost groups.

Structure of the presentation platform for the standardised listing of costs

Level 1	Level 2	Level 3	Activity	Labour cost	Investment	Expenses	Contingency	Total cost	User-defined data extensions			
01			Pre-decommissioning actions									
	01.0100		Decommissioning planning									
		01.0101	Strategic planning									
		01.0102	Preliminary planning									
		01.0103	Final planning									
	01.0200		Facility characterisation									
		01.0201	Detailed facility characterisation									
		01.0202	Hazardous-material surveys and analyses									
		01.0203	Establishing a facility inventory database									
	Etc.											
02			Facility shutdown activities									
03												
04												
05												
06												
08												
09												
10												
11												
Total												

Application of the ISDC to decommissioning costing

The report provides general guidance on the use of the ISDC cost structure, in particular on the following aspects:

- Definition of assumptions and boundary conditions – a detailed listing of typical assumptions and boundary conditions is provided to assist users in checking the completeness of the scope of activities included in the estimate.
- Quality assurance and traceability of data – guidance is provided on the management, updating and traceability of the data needed in order to develop a decommissioning cost estimate.
- Contingency provisions in cost estimates – guidance is provided on how a cost estimate should reflect contingency provisions to deal with uncertainties relating to activities within the defined project scope that might reasonably be expected to occur.

1. Introduction

1.1 Background

It is common practice that decommissioning plans and associated cost estimates are prepared for all nuclear installations. These estimates are important for ascertaining that the necessary funds are being collected to cover the costs of decommissioning the facility, i.e. the costs of the activities required to enable a disused nuclear facility to be removed from regulatory control. The activities in question include measurements of levels of radioactivity in materials, structures and soils, decontamination, dismantling of plant equipment, demolition of buildings and structures, and management of the resulting materials.

Decommissioning cost estimates may serve a variety of purposes, depending on the stage in the project lifetime at which the estimate is made, and the audience for the estimate varies accordingly. In the case of estimates undertaken at the conceptual design stage of a project, the main purpose is to enable designers and client organisations to establish overall project costs. When the project planning has advanced to the point that licensing approvals are being sought, the relevant authorities and affected stakeholders will need to be satisfied that arrangements will be put in place to ensure that the necessary funds to cover decommissioning costs will be available when needed, even in the event of a premature shutdown of the nuclear facility. At the end of the facility's period of operation, the cost estimate provides the basis for the detailed planning of the dismantling and site clean-up operations.

It has long been recognised that there is a considerable variety in the format, content and practice of cost estimates, often due to different national requirements about which activities should be included within the decommissioning cost estimate or to different assumptions about the time frame for decommissioning or about the final status of the site on which the facility is located. These differences make the process of reviewing estimates more complicated and result in a lack of transparency, i.e. it may be assumed that confidence in the veracity of estimates would be improved if it were easier to compare the results with other estimates for similar facilities.

The original version of this report [1], which was published in 1999, aimed to provide a standardised listing of cost items and associated definitions for decommissioning projects, in order to promote greater uniformity in estimates and thereby to facilitate better communication and to avoid misunderstanding of the conclusions from different cost evaluations. The proposed standardised cost structure has been adopted by several countries, either being used directly for the production of cost estimates or for mapping national estimates onto a common structure for purposes of comparison.

1.2 Scope

This report responds to the original intention that the standardised listing of cost items should be evaluated from time to time on the basis of the experience gained from its use, and that it should be updated on the basis of that evaluation. Such an evaluation was

performed in 2009 and this concluded that the update should focus on the following issues:

- ensuring greater overall coherence at the different hierarchical levels of the cost structure and the avoidance of ambiguities in the definitions of specific cost items; and
- providing guidance on the application of the standardised structure, thus promoting uniformity in its use.

The cost structure developed in the report may be used for estimating the costs of decommissioning of any type of nuclear facility. It is intended that all costs within the planned scope of the project may be reflected in the proposed structure. It may also be used as a point of departure for cost calculations relating to risks outside of the project scope, though this issue is not addressed in any depth.

1.3 Objective

The objectives of this report are two-fold:

1) to present an updated version of the standardised cost structure first published in 1999, which henceforth will be known as the International Structure for Decommissioning Costing (ISDC);
2) to provide general guidance on developing a cost estimate for decommissioning a nuclear facility and, in particular, on using the standardised cost structure.

1.4 Structure of the report

Chapter 2 of this report provides an introduction to cost estimation for decommissioning. This includes an overview of the main estimation approaches currently in use and a description of the close linkage between the cost estimate and the schedule of decommissioning activities. Chapter 3 presents the revised cost structure (ISDC) and Chapter 4 provides guidance on the application of the ISDC. The text is supported by the following appendices:

- Appendix A provides a summary of the cost item hierarchy.
- Appendix B provides a listing of assumptions and boundary conditions to be applied in cost estimating.
- Appendix C provides guidance on quality assurance of cost estimates and guidance on applying contingency factors.
- Appendix D provides standard definitions in the hierarchy, in terms of a description of the specific tasks that may be addressed by that cost item.
- Appendix E provides a glossary of terms.

2. Overview of cost estimation for decommissioning

2.1 Requirements and purposes of decommissioning costing

Owners/licensees are generally responsible for developing decommissioning plans, cost estimates and funding mechanisms [2, 3]. They are required to submit them to a designated competent authority, which may or may not be the nuclear safety regulator, for approval periodically. This usually occurs on a 3-5 year time frame. In some countries a cost benefit analysis is required in support of the decision to select a particular decommissioning strategy. The competent authority may also review the funding mechanism used to assure adequate funding for decommissioning.

Stakeholders are increasingly being involved in the review of decommissioning plans and of decisions about end point states and, sometimes, cost estimates and funding arrangements. The consultative process may be facilitated through a local information commission or community oversight board, which may comment on technical issues and influence the direction being taken for the decommissioning of the facility.

2.2 Types of costs and levels of accuracy

There are commonly three types of cost estimates that can be used and each has a different level of accuracy. These cost estimate types are summarised in the following paragraphs:

- Order-of-magnitude estimate: one without detailed engineering data, where an estimate is prepared using scale-up or -down factors and approximate ratios. It is likely that the overall scope of the project has not been well defined. The level of accuracy expected is -30% to +50%.
- Budgetary estimate: one based on the use of flow sheets, layouts and equipment details, where the scope has been defined but the detailed engineering has not been performed. The level of accuracy expected is -15% to +30%.
- Definitive estimate: one where the details of the project have been prepared and its scope and depth are well defined. Engineering data would include plot plans and elevations, piping and instrumentation diagrams, one-line electrical diagrams and structural drawings. The level of accuracy expected is -5% to +15%.

It is apparent from these estimate types and the associated levels of accuracy that, even in the most accurate case, a definitive estimate is only accurate to -5% to +15 %. The cost estimator needs to exercise his/her judgment as to the level that the input data will support. In developing a funding basis for a project, the estimator includes sufficient margin (or contingency) to account for a potential budget overrun.

2.3 Overview of estimating approaches

Costs may be estimated in a number of ways. Recorded experience from other decommissioning projects, estimating handbooks and equipment catalogue performance data are some of the sources used to develop cost data. The techniques used for preparing cost estimates will necessarily vary with the project's degree of definition; the

state-of-the-art of the project; the availability of databases, cost estimating techniques, time, and cost estimators; and the level of engineering data available. Some of the more common estimating techniques are described in the following paragraphs:

- Bottom-up technique: generally, a work statement and set of drawings or specifications are used to extract material quantities required for executing each discrete task performed in accomplishing a given activity. From these quantities, direct labour, equipment and overhead costs can be derived.
- Specific analogy technique: specific analogies depend upon the known cost of an item used in prior estimates as the basis for the cost of a similar item in a new estimate. Adjustments are made to known costs to account for differences in relative complexities of performance, design and operational characteristics.
- Parametric technique: parametric estimating requires historical databases on similar systems or subsystems. Statistical analysis is performed on the data to find correlations between cost drivers and other system parameters, such as design or performance. The analysis produces cost equations or cost estimating relationships that may be used individually or grouped into more complex models.
- Cost review and update technique: an estimate may be constructed by examining previous estimates of the same or similar projects for internal logic, completeness of scope, assumptions and estimating methodology.
- Expert opinion technique: this may be used when other techniques or data are not available. Several specialists may be consulted iteratively until a consensus cost estimate is established.

The bottom-up technique is widely adopted in estimating decommissioning costs, generally using a building in which the overall decommissioning project is divided into discrete and measurable work activities which may be assumed to be undertaken in a similar working environment. This division provides a sufficient level of detail so that the estimate for a discrete activity can apply to all occurrences of the activity [4]. For some costing methodologies the activities used for costing may be taken directly from the work breakdown structure (WBS) used for project management purposes. The WBS is used to categorise cost elements and work activities into logical groupings that have a direct or indirect relationship to each other.

The activities used for costing purposes are usually related to the accounting system, or chart of accounts used for budgeting and tracking major elements of the decommissioning costs. They are generally arranged in a hierarchical format. Accordingly, the topmost level of the cost structure encompasses the overall project; the second level reflects the major cost groupings under which project costs are gathered; the next level represents the principal component parts of each direct or indirect cost category for that cost grouping. Subsequent levels are often used to track details of the component parts of the grouping so that a clear understanding of all the cost bases can be made.

The project management or accounting software used on major projects usually identifies categories of costs in terms of a chart of accounts. The chart of accounts is where the individual cost items of labour, equipment, consumables, capital expenditures, recycle services, transportation or disposal services are budgeted and cost-controlled on a rigorous basis [5].

2.4 Cost element definitions

It is constructive and helpful to group elements of costs into categories to better determine how they affect the overall cost estimate. To that end, the cost elements are broken down into activity-dependent, period-dependent, and collateral costs as defined

in the following paragraphs. Contingency, another element of cost, is applied to each of these elements on a line-item basis (see below) because of the unique nature of this element of cost:

- Activity-dependent costs: activity-dependent costs are those costs associated directly with performing decommissioning activities. Examples of such activities include decontamination; removal of equipment; demolition of buildings; and waste packaging, shipping and disposal. These activities lend themselves to the use of unit cost and work productivity factors (or work difficulty factors) applied against the plant and structure's inventories to develop the decommissioning cost and schedule.
- Period-dependent costs: period-dependent costs include those activities associated primarily with the project duration: engineering, project management, dismantling management, licensing, health and safety, security, energy and quality assurance. These are primarily management staffing level costs, developed by estimating the manpower loading and associated overhead costs based on the scope of work to be accomplished during individual phases within each period of the project.
- Collateral and special item costs: in addition to activity and period-dependent costs, there are costs for special items, such as for procurement of construction or dismantling equipment, site preparation, insurance, property taxes, health physics supplies, liquid radioactive waste processing and independent verification surveys. Such items do not fall in either of the other categories. Development of some of these costs, such as insurance and property taxes, is obtained from owner-supplied data.
- Contingency: contingency can be defined as "a specific provision for unforeseeable elements of cost within the defined project scope, particularly important where previous experience relating estimates and actual costs has shown that unforeseeable events that increase costs are likely to occur" [5].

The cost elements in a decommissioning cost estimate are based upon ideal conditions where activities are performed within the defined project scope, without delays, interruptions, inclement weather, tool or equipment breakdown, craft labour strikes, waste shipment problems, or burial facility waste acceptance criteria changes, changes in the anticipated plant shutdown conditions, etc. However, as with any major project, events occur that are not accounted for in the base estimate. Therefore, a contingency factor is applied. Early decommissioning cost estimates included a contingency of 25% that was applied to the total project cost. More recent and accurate approaches apply contingencies on a line-item basis, yielding a weighted average contingency for the cost estimate. One source for the line-item contingencies is the AIF/NESP study [4], which discusses the types of unforeseeable events that are likely to occur in decommissioning and provides guidelines to apply for various activities.

The cost estimate includes an evaluation of the scrap and/or salvage values from materials that are determined to be clean, or that were never exposed to radioactive or hazardous material contamination. Salvage is defined as removed material that has an identified market for resale or reuse at a specific facility. Accordingly, pumps, motors, tanks, valves, heat exchangers, fans, diesel engines and generators are typical of components that are candidates for salvage. Scrap is defined as removed material that is certified to be non-contaminated or non-activated, and may be sold to a scrap dealer for ultimate recycling as a raw material. Examples of scrap material are copper wire and bus bars, stainless steel plates and structural members, carbon steel and stainless pipe, carbon steel structural shapes, beams and plates.

2.5 Overview of cost estimating process

A thorough cost estimating process flows from an overview of the project, to the scenarios evaluated or selected, to the assumptions critical to the approach, to the details of the cost elements and the work schedule, and then to a summary of the principal cost drivers. While there are no firm rules for formatting the process, there are logical guidelines to follow so that cost estimates can be easily tracked and compared:

- Scope of work: the scope of work for the project needs to be clearly stated at the outset of the estimate to ensure the estimator and reader understands what is included in the estimate, and the extent of effort required. The scope identifies assumptions and exclusions of the systems and structures to be removed and dismantled, and the amount of site restoration required.
- Decommissioning strategies: the decommissioning strategies to be evaluated, typically involving a choice between immediate dismantling, deferred dismantling and entombment.
- Collection of information: a site-specific estimate uses defined engineering data, including site and plot plans, general arrangement and architectural drawings, piping and instrument diagrams, one-line electrical diagrams, equipment specifications and reference manuals, to provide a basis for the facility systems and structures requiring decontamination and dismantling. Data collection includes the site radiological and hazardous material characterisation information; site specific inventory of systems and structures; local labour costs for skilled labour and management; local consumables and materials costs; taxes, insurance, engineering and regulatory fees.
- Preparation of the cost estimate: the application of unit costs to the inventory of systems and structures for each dismantling activity provides the activity-dependent costs. The estimate of the project management staff costs for the duration of the project provides the period-dependent costs. Collateral costs and contingency are added to develop the total decommissioning cost.
- Preparation of the schedule: the overall schedule is developed from a logical and planned sequence of activities. The duration of each activity is estimated from the individual activity steps, and the sequence evaluated to obtain the critical path to accomplish the work. Iterations are often necessary to arrive at a reasonable schedule. This activity is usually performed using scheduling computer software.

The decommissioning cost estimate and schedule are not stand-alone documents; they are an integral part of the planning for a project from the concept to the final implementation. The cost estimate and schedule are linked inseparably, as changes to the cost affect the schedule as to when activities may be accomplished, and changes to the schedule affect the overall cost. An accurate cost estimate and schedule provide the ability to track costs and project trends.

2.6 Identification of decommissioning strategies

The process of selecting a decommissioning strategy for a nuclear facility can be highly complex. The decision has to be based on numerous factors to comply with regulatory guidance, owner/licensee objectives, stakeholder interests, funding limitations, timing issues, technology availability and personnel knowledge factors. There are generally three accepted decommissioning strategies considered as potential approaches for facility disposition – immediate dismantling, deferred dismantling, and entombment [6]. The option of no-action is not generally considered as this would involve transferring the clean-up burden to a future generation.

These three strategies may be described as follows:

- Immediate dismantling

  This strategy commences shortly after shutdown, if necessary following a brief transition period to prepare for implementation of the decommissioning strategy. Decommissioning is expected to commence after the transition period and continues in phases or as a single project until an approved end state, generally including the release of the facility or site from regulatory control has been reached.

- Deferred dismantling

  Dismantling may be deferred for a period of up to several decades. Deferred dismantling is a strategy in which a facility or site is placed in a safe condition for a period of time, followed by decontamination and dismantling. During the deferred dismantling period, a surveillance and maintenance programme is implemented to ensure the required level of safety is maintained. During the shutdown and transition phases, facility-specific actions are necessary to reduce and isolate the source term (e.g. removal of spent fuel, conditioning or remaining operational or legacy waste) to prepare the facility/site for the deferred dismantling period.

- Entombment

  Entombment is a strategy in which the remaining radioactive material is permanently encapsulated on site. A low- and intermediate-level waste repository is effectively established and the requirements and controls for the establishment, operation, and closure of waste repositories are applicable. Because most power reactors will have radionuclides in concentrations exceeding the limits for unrestricted use even after 100 years, this strategy option will generally require long-term restrictions being placed on the use of the site.

2.7 Decommissioning phases, scope of work and major activities

Facility decommissioning follows deactivation (i.e. after shutting down operations and removing high risk large quantities of readily accessible radioactivity such as spent fuel, and sealed sources, and highly hazardous reactive chemicals such as bulk quantities of acids and bases). The decommissioning process can be described in four principal phases, each involving distinct, specific activities. Cost estimating and scheduling involves understanding these phases and the activities that must be performed to complete them.

- Preliminary planning

  The preliminary planning phase may begin early (before shutdown), and involves the preliminary assessment of decommissioning options, conceptual cost estimates and schedules, waste generation and disposition estimates, and exposure estimates to workers and the public. The objective is to define major options and a funding approach that will meet the owner/licensee needs and satisfy regulators.

- Detailed engineering

  The detailed engineering and evaluation phase covers planning and specific engineering feasibility evaluation. It normally begins after the facility is permanently shut down and when remaining radiological and hazardous material is stable and can be inventoried by measurement and calculation. This phase includes interaction with regulators and stakeholders for acceptance of the approach, particularly the proposed facility end state.

- Dormancy for deferred dismantling

  This phase (where applicable) involves placing the facility in safe storage for the dormancy period before deferred dismantling. It involves draining down systems, deactivating electrical systems not required during dormancy, removal of legacy wastes, modifying security systems, providing for environmental surveillance.

- Entombment

  This phase (where applicable) involves placing the facility in safe storage for entombment. It involves draining down systems, deactivating electrical systems not required during entombment, disposing of legacy wastes, modifying security systems, and providing for environmental surveillance. All radioactive systems and structures to remain are enclosed within an entombment boundary, and sealed to prevent inadvertent access.

- Operations for dismantling

  The operations or implementation phase is the actual hands-on activity for decommissioning. It may also involve removal, packaging, transportation and storage or disposal of systems and structures to meet end-state objectives. For example, for a nuclear power plant, this would include removal of the steam generators, pressurisers, reactor coolant pumps, reactor vessel and internals, all safety related systems and structures, the turbine-generator, condensate system, feedwater systems, water cooling systems, fire protection systems, and finally building dismantling. For fuel cycle facilities, this would involve the removal of the main process systems and equipment.

- Closeout and licence termination

  This phase is for the final demolition of structures and restoration of the site and final site survey to certify all radioactive material above acceptable levels has been removed and the licence may be terminated.

2.8 General factors influencing decommissioning strategy selection

The principal factors that influence strategy selection need to be addressed in a logical and transparent manner. The factors include:

- national policies and regulatory framework;
- financial resources/cost of implementing a strategy;
- spent fuel and waste management system;
- health, safety and environmental impact;
- knowledge management and human resources;
- social impacts and stakeholder involvement; and
- availability of suitable technologies and techniques.

Each of these principal factors needs to be further defined for the facility being decommissioned on a site-specific basis. Careful attention needs to be given to selection of the sub-factors and thoroughly evaluated during the preliminary planning phase to ensure all interests are properly served.

The identified factors and their associated sub-factors may be evaluated using a multi-attribute utility analysis (MUA) method [7]. The process involves listing all the factors and assigning numerical ratings and weightings to the factors, followed by comparison of the resultant total scores for the options. If necessary (e.g. when two options have very close scores), a sensitivity analysis can be performed to check whether or not the preferred option is a robust choice. But it should be noted that strategy selection studies (even when using formal methods such as MUA) involve aspects that are judgmental and subjective, potentially leaving the conclusions open to challenge. Increasingly, this

problem is being addressed by public involvement (stakeholder dialogue) in the strategy selection process. Workshop sessions involving a panel of experts can facilitate the selection process.

As selection of a decommissioning strategy usually occurs during the preliminary planning phase, it is important that the cost estimates used as a basis for selection are sufficiently robust. While much detailed costing information may not be readily available at this phase, assumptions and boundary conditions underlying the estimates need to be clearly stated and emphasised – see Appendix B. Experience suggests that this aspect of cost estimating is often overlooked or in some cases ignored, and decisions are made which may not be robust to all feasible options. The owner/licensee at the highest management levels must participate in selection of assumptions and evaluate each one in detail. Sensitivity studies at this stage serve an important role in understanding clearly the impact of each assumption on the final outcome. Management must be briefed on each assumption to be sure they understand its importance and how heavily the strategy decision depends on each such factor. When cost estimates for two or more strategies fall too close together, further sensitivity analyses need to be performed to separate out the important aspects so that a rational decision can be made.

3. Cost structure hierarchy

3.1 Overview

The ISDC provides a hierarchical structure of standard decommissioning activities which is intended to cover all types of activities identified in any decommissioning project for any type of nuclear installation, regardless of size, composition/complexity of systems and structures and radiological conditions. The typical representative decommissioning activities are organised into 11 groups of similar activities – Principal Activities – which broadly reflect the main phases of a decommissioning project.

One of the basic objectives in developing the ISDC is to provide a list of typical and representative decommissioning activities which occur in the ISDC only once. These representative decommissioning activities can be repeated in a real decommissioning project many times, depending mainly on the inventory structure of the nuclear installation to be decommissioned or on the definition of phases of the decommissioning project.

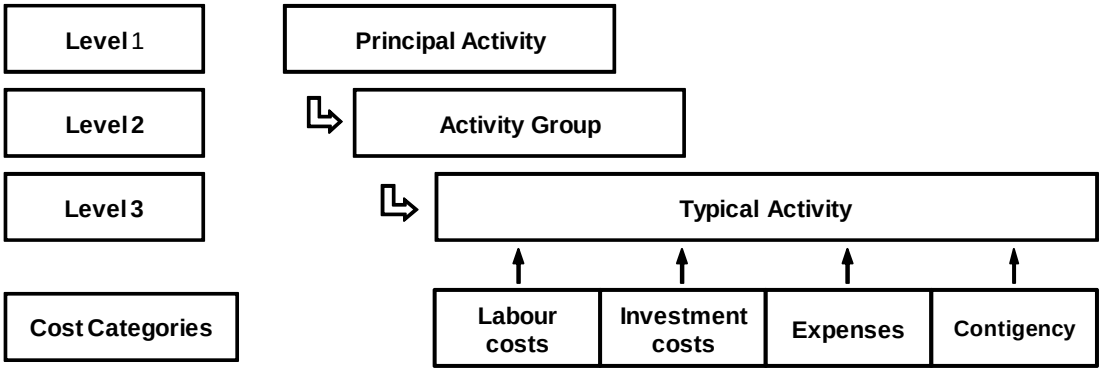
The system of numbering at the Principal Activity level is represented by a two-digit number, as follows:

01 – Pre-decommissioning actions.
02 – Facility shutdown activities.
03 – Additional activities for safe enclosure and entombment.
04 – Dismantling activities within the controlled area.
05 – Waste processing, storage and disposal.
06 – Site infrastructure and operation.
07 – Conventional dismantling, demolition and site restoration.
08 – Project management, engineering and support.
09 – Research and development.
10 – Fuel and nuclear material.
11 – Miscellaneous expenditures.

The system of numbering of lower level activities is based on a six-digit number, with the first two numbers representing the Level 1 activity (Principal Activity), the second two digits the Level 2 activity (Activity Group), with the third two digits defining the unique Level 3 activity (Typical Activity). Typical Activities are considered to be elementary decommissioning activities for which the cost is calculated within the cost structure. This is the lowest obligatory level of the ISDC – see figure below. The levels of detail and the extent of elementary decommissioning activities are closely related to the phase of decommissioning planning, starting from very preliminary estimates up to the detailed decommissioning plan.

A full listing of the activities which comprise the ISDC is provided in Appendix A for ease of reference. Appendix B provides a checklist of the assumptions and boundary conditions underlying the definition of activities used to develop the cost estimate.

Main hierarchical structure of the ISDC



The first and second levels are aggregating levels – see example in the box below relating to Activity Group 04.0500 "Dismantling of main process systems, structures and components".

Principal Activity	04 Dismantling activities within the controlled area.
Activity Group	04.0500 Dismantling of main process systems, structures and components.
Typical Activity	04.0501 Dismantling of reactor internals.
	04.0502 Dismantling of reactor vessel and core components.
	04.0503 Dismantling of other primary loop components.
	04.0504 Dismantling of main process systems in fuel cycle facilities.
	04.0505 Dismantling of main process systems in other nuclear facilities.
	04.0506 Dismantling of external thermal/biological shields.

The elementary decommissioning activities for costing purposes can be organised in the cost calculation structure according to the WBS for the decommissioning project or directly according to the ISDC by developing additional numbered levels (see Chapter 4). Additional numbering below the third hierarchical level is optional and can be used for example for differentiating individual phases of a decommissioning project or for decommissioning of complex installations such as reactors. Such additional numbering may also facilitate understanding of the ISDC items at the third level.

Phasing of decommissioning projects may lead to repetition of the same types of activities during various phases of the project. The use of additional, project-specific, numbering facilitates the distinguishing of parameters of individual phases of the decommissioning project.

3.2 First hierarchical level: Principal Activities

Principal Activity 01 "Pre-decommissioning actions" involves the activities which are undertaken prior to licensing of a decommissioning project, including contracting activities, if a principal contractor or multi-contractor model is implemented. The activities are graded beginning from preliminary cost feasibility studies (which may be undertaken even prior to the commissioning of the facility) up the level of detailed decommissioning documentation for licensing and planning. Most of these activities are specific engineering, planning and management activities, performed by the owner's staff and by contracting companies specialised in preparing decommissioning documentation.

Principal Activity 02 "Facility shutdown activities" involves the activities realised during the transition period after the shutdown until the licence for decommissioning is obtained [8]. The main purpose of these activities is to prepare the facility for decommissioning, using experienced operating personnel and, in specific cases, specialised services. In general, at the start of the active decommissioning phase (after performing all Principal Activity 02 activities), there is no historical/legacy waste (operational waste and historical radioactive waste) left in the facility, the systems are without any operating media and the primary systems are decontaminated using the operational procedures (perhaps requiring modification for more intensive decontamination) and personnel. This situation is hard to achieve in old facilities or facilities shutdown following an accident. In these cases, the assumptions and boundary conditions for a decommissioning project should define the starting position of the project in relation to Principal Activity 02.

Principal Activity 02 activities are sometimes paid from funds other than the decommissioning fund. This situation is country dependent and should be defined in the assumptions and boundary conditions of the decommissioning project. Some of the activities which represent a significant cost, such as the cooling down of the last remaining fuel, are included in Principal Activity 02, unless excluded according to national legislation related to decommissioning. This should be stated in the assumptions and boundary conditions for the project (see Appendix B).

Only the removal of operational waste is included in this Principal Activity, using existing operational procedures and personnel; materials needed for decommissioning (e.g. filters of ventilation, sources for calibration purposes, etc.) are assumed to remain in the facility. Further treatment, conditioning, transport and disposal of waste is included in the Principal Activity 05. Retrieval of historical/legacy waste is addressed in Principal Activity 05.

Principal Activity 03 "Additional activities for safe enclosure and entombment" involves the preparatory activities which need to be implemented for decommissioning scenarios involving deferred dismantling. These activities are required for preparation of the safe enclosure of the facility in order to ensure the long term stability and safety during the period of safe enclosure. This Principal Activity is not implemented in decommissioning scenarios with immediate dismantling. Where partial decommissioning of selected systems and buildings are envisaged during the phase of preparation of safe enclosure, the activities are addressed in Principal Activities 04 to 11.

For specific decommissioning scenarios of entombment, this Principal Activity involves also the preparatory activities required for achieving the final state of entombment. Other activities before achieving the final state are addressed in Principal Activities 04 to 11.

Principal Activity 04 "Dismantling activities within the controlled area" involves the activities involved in removing the contaminated and activated systems and structures from the controlled area and identified contaminated items outside of the controlled area. Prior to dismantling, there are procurement activities, preparation activities and pre-dismantling decontamination activities for ensuring safe dismantling. Dismantling is organised according to the type of facility and according to the components and materials to be removed. The removal of contamination includes also decontamination of building surfaces, removal of embedded elements within the premises and removal of contaminated components and soils outside of premises of the facility. No waste management is included in this Principal Activity. At the end of this phase the final radioactivity survey of buildings can be undertaken. The buildings are then ready for conventional demolition (Principal Activity 07), if this is part of the selected decommissioning strategy.

Principal Activity 05 "Waste processing, storage and disposal" involves all the activities involved in the management of the historical/legacy waste and for decommissioning waste resulting from actions undertaken in Principal Activity 04 (dismantling within the

controlled area, primary and secondary waste) and in Principal Activity 07 (dismantling outside of the controlled area and demolition of buildings). This Principal Activity includes, at the outset, the establishment of and operational support for the waste management system, which should cover all types of waste identified for the decommissioning project. The assumptions and boundary conditions for the decommissioning project should define the extent and types of waste to be handled including the management of the operational waste from Principal Activity 02 (which is in standard situations outside of the decommissioning project). The management of waste is organised according to the types of waste. The IAEA waste classification was implemented, as defined in the IAEA Safety Standard, Classification of Radioactive Waste, General Safety Guide, No. GSG-1 [9].

Where specific pre-treatment or treatment activities (such as fragmentation, decontamination, supercompaction, incineration) are required, these may be represented on a fourth hierarchical level of the cost structure, as defined by the user. Other waste management steps, including final conditioning, storage, disposal, transports and characterisation activities for each type of waste are addressed in the ISDC as third level activities. The end state for all types of waste is the disposal at repositories for radioactive waste for various levels of waste, repositories for hazardous waste or conventional dumps; and free release or conditional release of reusable materials. Waste management systems for decommissioning projects can be established also as shared systems, which cover several decommissioning projects. Decommissioning of the waste management system should be defined in assumptions and boundary conditions and implemented in Principal Activity 05.

Principal Activity 06 "Site infrastructure and operation" involves the activities concerned with site security and surveillance, site operation and maintenance, site upkeep, operation of support systems and radiation and environmental safety monitoring. These activities ensure the safety on the site and operability of auxiliary systems needed for supporting of the decommissioning activities.

The demand for these activities may be very different for individual phases of the project especially in the case of deferred dismantling and also during the main decommissioning period as the requirements are becoming less demanding as the decommissioning proceeds. Careful allocation of these activities is important.

Principal Activity 07 "Conventional dismantling, demolition and site restoration" is concerned with the activities for conventional dismantling of systems in premises outside of the controlled area and demolition of structures, both for buildings originally located within the controlled area (after their declassification, see Principal Activity 04) and for buildings outside the controlled area. Some of the buildings can be refurbished for further use or can be considered as assets arising from the decommissioning project. Activities include also the site clean-up and landscaping and the final survey of the site. The management of conventional and hazardous waste from dismantling and demolition is included in Principal Activity 05, where the management of all materials (inclusive radioactive waste) is addressed.

In some cases the site is released with defined restrictions which require additional funding for the period of restricted use of the site or its parts; this funding is included in the decommissioning cost. Principal Activity 07 includes items that may have considerable cost, especially conventional demolition work, so it is important to define the end state of buildings and site in the assumptions and boundary conditions for the decommissioning project. For example, the end state could involve: no demolition of buildings, demolition to the level of 1 m below ground level or complete demolition of concrete structures including foundations.

Principal Activity 08 "Project management, engineering and support" involves all types of activities concerned with management of decommissioning activities, engineering, technical, safety and other relevant support, during all phases of the decommissioning

project. Activities prior to the start of active decommissioning, such as mobilisation of personnel and establishment of the infrastructure for decommissioning and subsequent demobilisation activities after completion of the main decommissioning activities, are included.

Where a prime contractor is appointed to oversee the overall project or where contractors perform selected decommissioning activities, the cost of certain activities can differentiated between owner costs and contractor costs. The conditions for performing those activities can be different from the perspective of the owner and of the contractor, so these activities should be evaluated separately. These situations are addressed separately in the ISDC.

Another specific aspect for activities is the representation of activities of Principal Activity 08, which may need to vary according to the phases of the decommissioning project and also within individual phases. The extent of the activities of Principal Activity 08 can be very different, so that clear definition of different activities is important.

Principal Activity 09 "Research and development" involves all activities concerned with research and development specific to the decommissioning project, where the information available to the project is insufficient research and development work is typically is contracted to specialised institutions and companies. The simulation of complicated work on models may be done by the owner's staff or may be contracted to specialised institutions and companies.

Principal Activity 10 "Fuel and nuclear material" involves all activities defined within the decommissioning project for spent fuel and for nuclear materials. These activities may be paid from the decommissioning fund, owners' funds or from the state budget. This situation is country dependent and should be defined in the assumptions and boundary conditions of the decommissioning project.

Following a standard shutdown of a nuclear power plant (NPP), the spent fuel will often be transported from the cooling system in the reactor building to the external storage facility for long term storage. The particular situation can be very different for NPPs or some research reactors where the external storage facility is not available due to the type of the spent fuel, as a result of damage to the spent fuel or due to other reasons. In these cases, the buffer storage for spent fuel and/or nuclear materials should be considered within the decommissioning project (construction, licensing, operation, decommissioning) and also transfer of spent fuel and/or nuclear materials away from this buffer storage.

Non-typical cases may occur for some research reactors, other experimental facilities and also for fuel cycle facilities, e.g. special programmes have been implemented for repatriation of high enriched fuel for research reactors.

Decommissioning of large spent fuel storage facilities, such as the fuel stores for nuclear power plants, is normally organised as a separate decommissioning project.

Principal Activity 11 "Miscellaneous expenditures" involves cost items which are directly related to a decommissioning project (i.e. are within the project scope) but cannot be allocated to Principal Activities 01 to 10. Examples of these items are the transition schemes which compensate local communities for the shutdown of the facility or the consequences of decommissioning, pension schemes or requalification projects for personnel departing from the nuclear facility to be decommissioned, payments to authorities and various specific external services or payments with no direct allocation to Principal Activities 01 to 10. Taxes and insurances are other items.

In some decommissioning projects, assets can be identified in relation to sale of re-usable equipment or materials as the result of the activities in Principal Activity 02,

Principal Activity 04 or Principal Activity 07. Reuse of the site may play an important role in some cases.

3.3 Second and third hierarchical levels: Activity Groups and Typical Activities

This chapter explains the meaning of ISDC items at the second and third hierarchical levels, organised according to Principal Activities 01 to 11. A full listing of the ISDC activities is provided in Appendix A. Detailed examples of cost items normally included within each of the Level 3 ISDC activities are provided in Appendix D and a glossary of terms is provided in Appendix E.

3.3.1 Principal Activity 01: Pre-decommissioning actions

01.0100 Decommissioning planning.

- 01.0101 Strategic planning.
- 01.0102 Preliminary planning.
- 01.0103 Final planning.

01.0200 Facility characterisation.

- 01.0201 Detailed facility characterisation.
- 01.0202 Hazardous-material surveys and analyses.
- 01.0203 Establishing a facility inventory database.

01.0300 Safety, security and environmental studies.

- 01.0301 Decommissioning safety analysis.
- 01.0302 Environmental impact assessment.
- 01.0303 Safety, security and emergency planning for site operations.

01.0400 Waste management planning.

- 01.0401 Establish waste management criteria.
- 01.0402 Develop a waste management plan.

01.0500 Authorisation.

- 01.0501 Licence applications and licence approvals.
- 01.0502 Stakeholder involvement.

01.0600 Preparing management group and contracting.

- 01.0601 Management team activities.
- 01.0602 Contracting activities.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

The activities comprising Activity Group 01.0100 "Decommissioning planning" are normally undertaken at progressively increasing levels of detail:

- The first stage of decommissioning planning is addressed in the cost item strategic (or conceptual) planning (01.0101) at the feasibility stage of a decommissioning project. In some countries, this level of decommissioning planning is already required at the time of commissioning of the facilities. In the case of old facilities operated without any conceptual decommissioning documentation, this may be the first step in preparing for decommissioning.
- During the operation of the facility, these conceptual plans are periodically updated, initially representing preliminary planning (i.e. the preliminary decommissioning plan) (01.0102), and ultimately final planning (i.e. the final decommissioning plan) (01.0103), which is normally finalised during the transition period. The final decommissioning plan is the key document [10]

supporting the application for a decommissioning licence. Decommissioning planning activities in cost calculation schemes may be reflected in several packages, graded according to the extent and detail of individual packages. Facility characterisation in preliminary planning steps is reflected in 01.0101 and 01.0102. Facility characterisation for planning is addressed in Activity Group 01.0200. Planning activities are performed mostly as contracted specialised engineering activities; in large facilities, this activity may be undertaken directly by the owner. Planning for the transition period from operation to shutdown in relation to decommissioning is also included in Activity 01.0103.

Activity Group 01.0200 "Facility characterisation" is concerned with developing the data for facility systems and structures and the site, involving physical, radiological and material characterisation. These detailed data are needed for preparing the final decommissioning plan. Prior to item 01.0200, the characterisation activities are performed following a graded approach in several campaigns starting from mostly paper works in preliminary stages of decommissioning planning 01.0101 and later in 01.0102. Facility characterisation may be performed by specialised engineering contractors, supported by operational personnel, though in some cases all personnel will be supplied by the owner. Inventory data collected during facility characterisation support the safety analysis, decommissioning planning, waste management planning and costing. Facility characterisation is especially important for facilities with non-standard operation events or accidents.

- Detailed facility characterisation (01.0201) is the main source of information for Activity Groups 01.0300 and 01.0400. Final characterisation can be broken down into several packages such as: analysis of existing documentation (such as design, operation, changes during operation); direct inspection of systems, structures and the site; collecting information from operational personnel; modelling and calculation of activation and contamination; dose modelling or other specific activities. The data collected or elaborated in 01.0201 are updated to final values in 02.0400, for relevant locations, after removal of operating media, primary system decontamination, drainage and drying of systems and removal of all operational waste media.
- Hazardous-material surveys and analyses (01.0202) are performed in parallel to facility characterisation. The main outputs are data for waste management planning and also for decommissioning planning and safety analysis. With the exception of inventory estimation processes based on modelling, similar approaches as for facility characterisation are used.
- Establishing a facility inventory database (01.0203) involves the establishment of a systematic structure for the facility inventory database which is used for costing, safety evaluations and for planning. The data collected in 01.0201 and 01.0202 are introduced into the systematic facility inventory decommissioning database and are systematically maintained and/or updated.

Activity Group 01.0300 "Safety, security and environmental studies" is concerned with studies and analyses which are a pre-requisite for obtaining a decommissioning licence. Depending on the requirements of relevant national legislation, the safety evaluation for shutdown activities may be excluded from this item; in these cases the activities are typically funded from special owners' funds, i.e. are not charged to the funds set aside for decommissioning.

- Decommissioning safety analysis (01.0301) involves all analyses/assessments (nuclear, radiological and industrial safety aspects) undertaken for evaluation of safety of transition-period activities (after shutdown) and for planned decommissioning activities according to the scope of the decommissioning plan. The results of this analysis are used to support the selection of an optimal

decommissioning strategy (including the associated waste management system), for elaboration of the decommissioning plan, for detailed planning and for elaboration of planning documents related to cost item 01.0303.

- Environmental impact assessment (01.0302) involves activities which are performed according to the legislation of the given country. The outputs from these activities are separate documents which are normally a pre-requisite for decommissioning licensing.
- Safety, security and emergency planning for site operations (01.0303) involves activities related to elaboration of all documents of this type which are required by national decommissioning legislation. Most of the documents are normally part of the documentation package for licensing.

The definition of cost items under Activity Group 01.0400 "Waste management planning" reflects the importance of the waste management plan in decommissioning planning, especially in cases of facilities with historical/legacy waste, facilities shutdown following an accident, non-standard waste or decommissioning cases where the waste management systems is shared with other decommissioning projects or facilities in operation (multi-facility sites). The waste management plan is the base document for the planning of activities of Principal Activity 05.

- The activities comprising Activity Group 01.0400 are performed in parallel with decommissioning planning as a group of specific planning activities aimed at establishing waste management criteria (01.0401) for relevant parts of decommissioning process and for waste management planning such as the acceptance criteria for individual waste processing techniques, for release of materials and for disposal of conditioned waste.
- The cost item "Develop a waste management plan" (01.0402) is concerned with the development of a waste management plan based on the selected decommissioning strategy, facility inventory and data prepared in 01.0401. The plan should involve all types of waste resulting from decommissioning and, depending on the conditions at the start of decommissioning as defined in assumptions and boundary conditions of the decommissioning project, including historical and legacy waste. Processing of operational waste is normally undertaken as an operational activity under the operational licence, and paid from owners' funds.

The activities comprising the Activity Group 01.0500 "Authorisation" include actions needed to submit the application for obtaining the decommissioning licence and the subsequent licence assessment process.

- Licence applications and licence approvals (01.0501) addresses the preparation and submission of all documents needed for decommissioning licensing, which documents are developed under Activity Groups 01.0100 to 01.0400, and the preparation of all other documents required by relevant national legislation; managing the licensing process from the owner's side and all expenditures related to licensing. In the case of the decommissioning programmes with several licensed decommissioning phases, activity 01.0501 addressed the granting of licences for the first decommissioning phase. Licences for subsequent decommissioning phases (where required) and other partial licences (if needed for specific decontamination and/or dismantling activities) are addressed by 08.0201 and 08.0202.
- Stakeholder involvement (01.0502) includes all activities of relevant stakeholders needed for obtaining the decommissioning licence. Activities are included, which can be funded from the decommissioning fund according to the national legislation or from the state budget in the case of state-owned facilities.

The activities comprising the Activity Group 01.0600 "Preparing management group and contracting" involve activities of specialised group in the frame of preparing of decommissioning prior to start of decommissioning.

- Management team activities (01.0601) involve activities for managing and support of activities 01.0100 to 01.0500 and 01.0602 for preparation of decommissioning prior to the start of the decommissioning. After obtaining the decommissioning licence, this team will normally become the core of the project manager group – see Activity Group 08.0200. The size of the group will vary as the project moves through different phases, sometimes comprising only a single person when decommissioning will not take place for a long period, up to several tens of people at the time of licensing of large decommissioning projects. The activities of 01.0601 should not duplicate activities in Activity Groups 01.0100 to 01.0500.
- Contracting activities (01.0602) are specialised activities for the development and management of contracts. They should not be understood as a subgroup of 01.0601. The activities facilitate comparison of the cases with or without contracting. Activities prior to the start of decommissioning are included here; contracting during decommissioning project is included in Activity Group 08.0200. Any overlap with cost item 01.0601 should be avoided.

Determination of costs and financing for Principal Activity 01

Detailed planning (01.0103) typically includes transition planning for the period from shutdown to the start of decommissioning. The inclusion of these activities in the decommissioning cost estimates is generally determined by relevant national regulations. In some countries, these activities are not funded from decommissioning fund, being regarded as operational activities, or by special funds allocated by the owner for the transition period. This is generally the case for NPPs; the approach may differ for smaller facilities such as research reactors or for state-owned research facilities. The inclusion of transition period activities should be clearly stated in the assumptions and boundary conditions, as this may have implications for the source of funds.

Similarly, in some countries, the safety analysis undertaken in 01.0301 and safety planning in 01.0303 for the transition period is not included in safety planning for decommissioning. In these cases, the analysis and safety planning is funded separately by the owner. National legislation generally defines which activities can be funded from state-controlled decommissioning funds.

Accurate costing of sub-activities of Principal Activity 01 relies on having clear definitions in assumptions and boundary conditions for the decommissioning project, including definition of which activities are funded from the decommissioning fund (or directly from the state budget) and how the transition period is addressed in decommissioning planning.

- The preliminary stages of planning (activities 01.0101 and 01.0102), which generally occur several years or decades before the start of decommissioning, are normally paid from owners' funds.
- Planning in Principal Activity 01 includes the elaboration of documents required for licensing. The development of realisation plans for performing the decommissioning activities is included in 08.0202.
- Overlapping of activities between different ISDC activities should be avoided, e.g. activity 01.0601 should be clearly separated from Activity Groups 01.0100 to 01.0500.

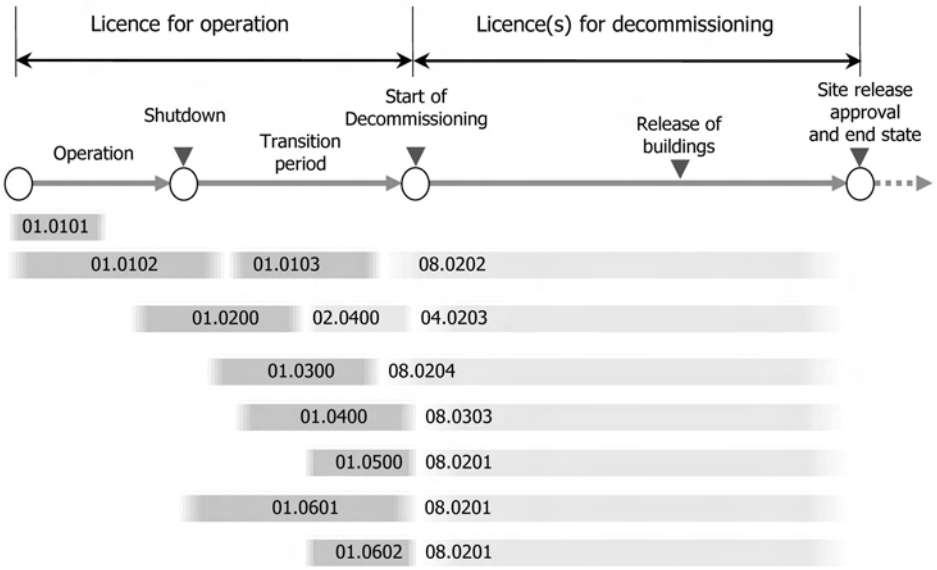
Sub-activities of Principal Activity 01 are relevant also for fuel cycle facilities. The transition period for these facilities should be clearly defined in assumptions and

boundary conditions. In the case of small facilities such as research reactors or laboratories, costs may need to be estimated at the Activity Group level, where the available data do not support greater levels of precision.

In the case of decommissioning projects with several licensing phases, the sub-activities of Principal Activity 01 are repeated prior to licensing of individual decommissioning phases. The cost for these activities should be included in the relevant items of Principal Activity 01.

Completion of Principal Activity 01 corresponds to the situation at the end of the transition period when the decommissioning licence has been obtained and the facility is ready for start of decommissioning activities.

Typical schedule for decommissioning activities of Principal Activity 01



Note: Activities shown in light grey are equivalent to sub-activities of Principal Activity 08 undertaken under the decommissioning licence. Activity Group 02.0400 is the continuation of Group 01.0200 during the transition period for completing the data collection, following drainage, drying and decontamination of systems.

3.3.2 Principal Activity 02: Facility shutdown activities

02.0100 Plant shutdown and inspection.

02.0101	Termination of operation, plant stabilisation, isolation and inspection.
02.0102	Defueling and transfer of fuel to spent-fuel storage.
02.0103	Cooling down of spent fuel.
02.0104	Management of fuel, fissile and other nuclear materials.
02.0105	Isolation of power equipment.
02.0106	Facility reuse.

02.0200 Drainage and drying of systems.

02.0201	Drainage and drying of closed systems not in operation.
02.0202	Drainage of spent-fuel pool and other open systems not in operation.
02.0203	Removal of sludge and products from open systems.
02.0204	Drainage of special process fluids.

02.0300 Decontamination of closed systems for dose reduction.

02.0301	Decontamination of process installations using operational procedures.
02.0302	Decontamination of process installations using additional procedures.

02.0400 Radiological inventory characterisation to support detailed planning.

02.0401	Radiological inventory characterisation.
02.0402	Underground water monitoring.

02.0500 Removal of system fluids, operational waste and redundant material.

02.0501	Removal of combustible material.
02.0502	Removal of system fluids (water, oils, etc.).
02.0503	Removal of special system fluids.
02.0504	Removal of waste from decontamination.
02.0505	Removal of spent resins.
02.0506	Removal of specific operational waste from fuel cycle facilities.
02.0507	Removal of other waste from facility operations.
02.0508	Removal of redundant equipment and materials.

General features of Principal Activity 02

The initial status of reactor facilities for Principal Activity 02: the facility is in shutdown mode; the last remaining fuel is in the reactor; operational system fluids remain in the systems, operational waste (volumes and location) are as during the operation. In old facilities, historical/legacy waste may be present. For facilities shutdown after accident additional special waste may be present as a result of the accident; in some cases the fuel is damaged and will require special procedures for retrieval and transport. Auxiliary systems are in operation to the same extent as during the operational period.

The initial status of fuel cycle facilities for Principal Activity 02: the facility is in shutdown mode; there are no nuclear materials remaining in the processing systems; the presence of processed nuclear materials (volumes and locations) is as during the operational phase; operational system fluids remain in the systems; operational waste including the high-level waste (HLW) (volumes and locations) is present as during the operation. Auxiliary systems are assumed to be in operation to the same extent as during the operational period.

The management of waste in Principal Activity 02 includes the removal activities up to the point when the waste is transported to the location for further processing. The cost of any processing is not included.

The end state of facilities on completion of Principal Activity 02: after completing the activities of Principal Activity 02, the relevant facility (reactor, fuel cycle facility or laboratory) will be free of any operational waste, prior to obtaining the decommissioning licence or equivalent authorisation. The systems are empty and dry, though some residues may be assumed to remain. This situation will normally be achieved for facilities after standard operation and standard shutdown. There will also be cases, such as old facilities and facilities shutdown after accident, with accumulated historical/legacy waste, research reactors with accumulated experimental equipment and materials, where this status is not achieved. This situation should be clearly stated in the assumptions and boundary conditions for the relevant decommissioning projects. In these cases, specific additional activities are included within the scope of licensed decommissioning activities. This should be defined in the decommissioning plan and approved in the licence.

Sub-activities of Principal Activity 02 are performed under the operating licence.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

The aim of Activity Group 02.0100 "Plant shutdown and inspection" is to ensure nuclear and radiation safety during the shutdown activities; to manage spent fuel and nuclear materials (i.e. no spent fuel, no nuclear materials present at the end of shutdown activities, prior to obtaining the decommissioning licence); and to bring the facility systems to the status of being ready for decommissioning or reuse, where relevant.

- Termination of operation, plant stabilisation, isolation and inspection (02.0101) involves all activities related to the operation of auxiliary systems as required during shutdown activities with respect to cooling down of spent fuel; sequential modification and/or shutdown of auxiliary systems according to the shutdown requirements up to the extent needed for supporting the decommissioning activities at the start of decommissioning, preservation and surveillance measures to ensure nuclear safety in the facility during the transition period; these activities relate to reactor and fuel cycle facilities and to laboratories.
- Defueling and transfer of fuel to spent-fuel storage (02.0102) involves activities for transfer of fuel from reactors to temporary spent fuel storage facilities in reactor buildings and/or to buildings outside of reactor building (e.g. as may occur for research reactors). For standard NPPs, this can be a minor cost item; for NPPs shutdown following an accident with damaged fuel, this item can represent a significant cost. The transfer of fuel from the reactor to a temporary spent fuel storage facility may include several steps, e.g. as is the case for gas cooled reactors when changing the cooling media. As regards research reactors, the cost depends on specific procedures and arrangements for spent fuel management; external temporary spent fuel stores may be included into decommissioning projects for research reactors. The end state of the item is having the fuel in storage away from the reactor.
- Cooling down of spent fuel (02.0103) comprises activities needed to ensure nuclear safety during the cooling down of the spent fuel. This is a separate item due to fact that, in some countries, these activities are funded from state-controlled decommissioning funds. For countries where this item is not relevant, the item is not used. This item can represent a significant cost especially for large multi-unit NPPs with operational systems with mutual technical links. For research reactors this is generally a minor or insignificant cost item. It is not relevant for fuel cycle facilities.
- Management of fuel, fissile and other nuclear materials (02.0104) is a common item for reactor facilities and for fuel cycle activities. For reactor facilities, this involves activities for management of non-irradiated or partially irradiated nuclear fuel in preparation for its possible reuse (such as preparation for transport, transport to the ultimate destination); for fuel cycle facilities this item represents activities for the management of products of these facilities such as uranium, enhanced uranium and plutonium, depending on type of the fuel cycle facility (preparation for transport, transport to the ultimate destination). The end state for both types of facilities is free of any nuclear materials.
- Isolation of power equipment (02.0105) involves specific activities for permanent isolation and disconnecting of power generating equipment from the grid in the reactor facilities for producing the electricity.
- Facility reuse (02.0106) involves activities for modification and/or refurbishment of selected systems or buildings which will be reused outside of the decommissioning project or in cases when they have an asset value.

The aim of Activity Group 02.0200 "Drainage and drying of systems" is to bring the operational systems to the status "empty and dry", where relevant. The subject of

activities are the systems with standard operational fluids such as water, oils and special system fluids such as heavy water, sodium and other fluids. On completion of activities, the systems fluids are ready for transport to waste treatment facilities.

- Drainage and drying of closed systems not in operation (02.0201) involves activities for drainage of these systems using the procedures as in the operational period including blowdown and drying. No decontamination is considered here. Additional activities may be added to remove sludge from the closed systems. Subsequent activities for removal of system fluids and also radioactive liquids are included in Activity Group 02.0500.
- Drainage of spent-fuel pool and other open systems not in operation (02.0202) involves activities for spent fuel pool (after transfer of the spent fuel outside of the pool) and for other open systems in reactor facilities and in fuel cycle facilities. Subsequent activities for removal of generated liquid waste are addressed in 02.0500. As part of the drainage, some preliminary decontamination may be applied, using easy-to-use techniques such as high pressure water jetting. After drainage of systems, the sludge and other residuals (fragments of spent-fuel or other specific objects) may remain in the systems, such as spent fuel pools, open processing systems in fuel cycle facilities or large storage tanks with external access to the interior of the tanks; these are addressed in 02.0203. In the case of pool reactors, the pool is not drained if the segmentation process involves underwater cutting.
- Removal of sludge and products from open systems (02.0203) involves removal of sludge and special items (fragments of spent fuel or other specific objects) after drainage of open systems within the item 02.0202. This item can be significant in the case of fuel cycle facilities, old facilities, facilities with long-term operation, and facilities with special historical and legacy waste or facilities shutdown following an accident. Some easy-to-use preliminary decontamination techniques may be applied.
- Drainage of special process fluids (02.0204) involves removal of special system fluids such as heavy water, sodium, and also cooling gases such as carbon dioxide, helium and other cooling gases in reactor facilities. The aim is to bring the operational systems containing special system fluids to the status “empty and dry”, where relevant. Drainage involves activities for transfer of the special system fluids from the systems into the storage and transport systems. Activities may include cleaning of special system fluids (gases) before their removal, using the operational systems for these purposes. The removal of drained special system fluids is addressed in 02.0500.

The aim of the Activity Group 02.0300 “Decontamination of closed systems for dose reduction” is to reduce the dose rates from the system components in order to facilitate the dismantling activities.

- Decontamination of process installations using operational procedures (02.0301) involves activities using similar technical means and procedures for system decontamination as are used during operation. These procedures are performed by operational personnel and may be modified for more aggressive decontamination using specific processes which are normally not included within standard operational procedures.
- Decontamination of process installations using additional procedures (02.0302) involves procedures performed by operational personnel and may be modified for aggressive decontamination with specific processes not usually included within standard operational procedures. Involvement of a small number of specialised non-operational personnel, where applicable, is included. Activities

for preparation and modification of procedures, procurement of special materials, modification of decontamination systems are included in this activity.

- Other approaches for decontamination of closed systems, using external decontamination systems (together with technical modification of closed operational systems), are not included here; these are addressed in Activity Group 04.0200.

The aim of the Activity Group 02.0400 "Radiological inventory characterisation to support detailed planning" is to update the facility inventory data developed in 01.0200. After drainage, blowdown, drying and decontamination, no other changes will be performed on systems until the start of pre-dismantling decontamination and dismantling activities. At this stage (performed during the transition period) the radiological data are checked once again where relevant and additional samples may be taken. The data are used for detailed planning and safety assessment of decontamination and dismantling activities.

- Radiological inventory characterisation (02.0401) involves activities for on-site inspection of plant and system components, including additional computer modelling where the data are expected to be affected by drainage, blowdown, drying and system decontamination.
- Underground water monitoring (02.0402) involves activities for obtaining final radiological data on soils and underground water. Except of detailed planning of activities, the data from both items 02.0501 and 02.0502 are used also for detailed planning in waste management.

The aim of Activity Group 02.0500 "Removal of system fluids, operational waste and redundant materials" is to achieve the status of the facility being free of any operational waste. In some countries this activity is obligatory prior to the commencement of formal decommissioning. Waste is transported to the treatment facilities; no subsequent treatment of the removed waste is included here.

- Removal of combustible material (02.0501) involves activities for removal of hydraulic fluids, solvents, unused cables, etc.
- Removal of system fluids (water, oils etc.) (02.0502) involves activities for removal of system fluids drained in item 02.0201 to 02.0203; its transfer for further processing in auxiliary systems of the facility using the same procedures as are applied during the operational period (cleaning the water on sorbents or by evaporation, and discharging/monitoring).
- Removal of special system fluids (02.0503) involves activities for removal of special system fluids drained in item 02.0204.
- Removal of waste from decontamination (02.0504) involves activities for removal of decontamination fluids generated in item 02.0300.
- Removal of spent resins (02.0505) involves activities for removal of operational spent resigns.
- Removal of specific operational waste from fuel cycle facilities (02.0506) involves activities for removal of HLW to vitrification facilities and removal of all other operational waste specific to fuel cycle facilities.
- Removal of other waste from facility operations (02.0507) involves activities for removal of other operational waste accumulated during operation of the facility, e.g. in some facilities high-level metallic waste may be stored in special shafts in the reactor hall. Accumulated waste must be removed prior to dismantling; in

some cases remote controlled techniques are used. The cost of these activities may be significant.

- Removal of redundant equipment and materials (02.0508) involves the removal and/or transfer of equipment and surplus spare parts which became redundant during the transition period. Operating personnel and operational procedures are used for these activities.

Determination of costs and financing for Principal Activity 02

- Relationship to the transition period

According to IAEA Technical Report Series 420 document [8], the transition period is defined as the period between shutdown of the facility and receipt of the decommissioning licence. During the transition period, various activities are performed to facilitate subsequent decommissioning. It should be noted that not all activities performed during the transition period are addressed within Principal Activity 02 "Facility shutdown activities" (see below).

Users of the ISDC should distinguish between listed activities as the *systematic list* of typical decommissioning activities and the transition period as the *time interval* in the facility life cycle. The majority of activities of Principal Activity 01; all activities of Principal Activity 02; preparatory, starting and minor activities of Principal Activities 03 to 11 are performed during the transition period. Additional guidance on the definition of decommissioning activities is provided in [8] – see Chapter 1.2 in particular, e.g. some minor dismantling and also some demolition activities are presented as activities performed during the transition period. Performance of these activities during the transition period is subject to relevant approvals of the regulatory bodies and by specific requirements of national legislation.

- Financing the facility shutdown activities

Principal Activity 02 activities can be funded from various financial sources such as the decommissioning fund, owner's fund for the shutdown of the facility or owner's operational financial means and also the state budget in the case of state-owned facilities. National legislation normally defines which decommissioning activities can be funded from these funds and the detailed approach will normally vary from country to country. The assumptions and boundary conditions of a decommissioning project should define the extent of decommissioning activities in relation to Principal Activity 02.

In general, only those activities within Principal Activity 2 that are funded from the decommissioning fund are included in a decommissioning cost estimate, with activities that are funded from owners' funds being evaluated separately.

The majority of activities of the Principal Activity 02 are performed by the operating personnel; the specialised activities which are not in line with operational procedures are performed by personnel considered as specialised decommissioning personnel or as contracted activities. Managing of activities of the Principal Activity 02 is performed by the group defined in 01.0601. In principle, the operating personnel can perform activities funded from decommissioning fund, from owners' funds for shutdown activities and from operational means of the owner. In this way, the cost of the operational personnel may be shared among the above listed financial sources; the task of decommissioning costing is to define and evaluate the cost for activities funded from the decommissioning fund. The situation can be different in state-owned facilities such as research reactors.

- Radiological characterisation

Several stages of radiological characterisation may be distinguished during decommissioning, with the first stages being performed as part of conceptual planning.

Operational data are largely used during the early stages, later complemented with data obtained from computer calculations, such as preliminary evaluations of activation; the data are complemented also by data acquired by pant inspections. These activities are included in conceptual planning, cost item 01.0102. The procurement of data for detailed planning for the final decommissioning plan is included in Activity Group 01.0200. Procurement of additional data after drainage and decontamination, required for detailed planning of decontamination and dismantling activities, is included in Activity Group 02.0400. Final checking of radiological data may be regarded as part of the preparatory activities performed at the start of decontamination and dismantling activities prior to gaining entry to individual premises by the personnel performing the decontamination and dismantling activities – see Principal Activities 03-04.

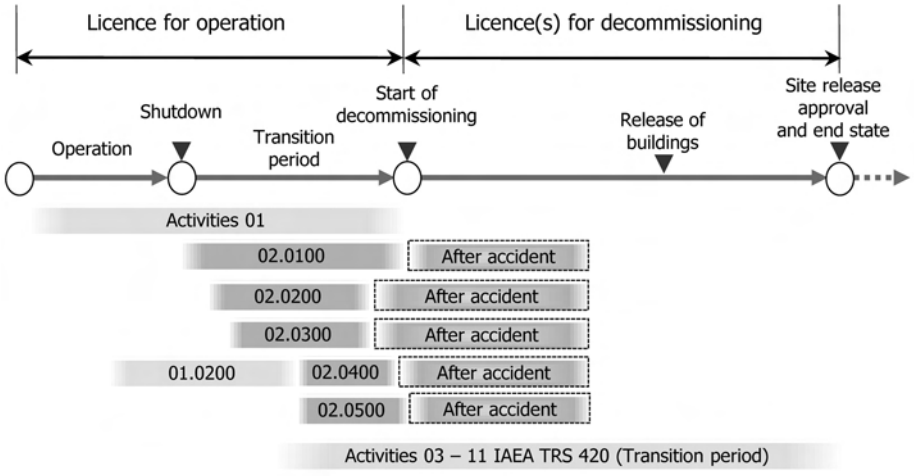
- Removal *vs*. dismantling

Only removal of equipment and/or surplus spare parts using the operational and/or maintenance means and procedures is included for the purpose of assets (e.g. income from the sale of spare parts, redundant operational equipment and tools as examples). Dismantling of equipment is generally not included in Principal Activity 02. Dismantling of equipment which is no longer used (e.g. after modification of auxiliary systems) is included in Principal Activity 04, and partially also in Principal Activity 03.

- Post-accidental situations

In nuclear facilities shutdown following an accident, some activities of Principal Activity 02 may continue also under decommissioning licence, e.g. due to the long duration and extent of transition-period activities. Selected activities which do not affect performance of the main activities of Principal Activities 04, 05, 07 may be performed in parallel. This should be stated in the assumptions and boundary conditions and also in conditions for obtaining the decommissioning licence. This situation is presented in the typical scheme for Principal Activity 02 below.

Typical schedule for decommissioning activities of Principal Activity 02



Note: The last row represents the time frame of the transition phase activities.

3.3.3 Principal Activity 03: Additional activities for safe enclosure or entombment

03.0100 Preparation for safe enclosure.

03.0101 Decontamination of selected components and areas to facilitate safe enclosure.

03.0102 Zoning for long-term storage.
03.0103 Removal of inventory not suitable for safe enclosure.
03.0104 Dismantling and transfer of contaminated equipment and material to containment structure for long-term storage.
03.0105 Radiological inventory characterisation for safe enclosure.

03.0200 Site boundary reconfiguration, isolating and securing structures.

03.0201 Modification of auxiliary system.
03.0202 Site boundary reconfiguration.
03.0203 Construction of temporary enclosures, stores, structural enhancements, etc.
03.0204 Stabilisation of radioactive and hazardous waste pending remediation.
03.0205 Facility controlled area hardening, isolation for safe enclosure.

03.0300 Facility entombment.

03.0301 Facility entombment as end state of decommissioning strategy.
03.0302 Institutional control and monitoring of the entombment end state.

General features of Principal Activity 03

The initial status of facilities in relation to Principal Activity 03 corresponds to the end status of Principal Activity 02. Procurement of equipment for Principal Activity 03 is not defined as a separate item, and no specialised equipment is assumed to be needed. Investment costs are included in relevant individual items.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

The activities of Activity Group 03.0100 "Preparation for safe enclosure" are those activities undertaken in order to reach a stable situation in anticipation of safe enclosure.

- Decontamination of selected components and areas to facilitate safe enclosure (03.0101) involves the decontamination of selected areas and systems which will require periodic servicing, maintenance, inspection and/or surveillance during the period of the safe enclosure by improving the radiological conditions by decontamination of selected systems and structures. In order not to repeat the pre-dismantling activities undertaken in Principal Activities 03 and 04, the activities listed in 04.0300, when needed, will be implemented during the preparation of the safe enclosure as sub-activities of Principal Activity 04, in parallel to the activities of Principal Activity 03.
- Zoning for long-term storage (03.0102) involves activities for outlining and realisation of new physical boundaries of the controlled area of the safe enclosure and modification of auxiliary systems within the controlled area to the level needed for the safe enclosure period.
- Removal of inventory not suitable for safe enclosure (03.0103) involves activities for partial removal of equipment and/or hazardous materials which are not suitable for long term storage.
- Dismantling and transfer of contaminated equipment and material to containment structure for long-term storage (03.0104) involves activities for partial dismantling and/or packaging of equipment and materials which will remain under safe enclosure.
- Radiological inventory characterisation for safe enclosure (03.0105) includes obtaining new radiological data for inventory, dose rate and contamination within the safe enclosure after the completion of the Activities 03.0201 to 03.0203.

Activity Group 03.0200 "Site boundary reconfiguration, isolating and securing structures" comprises activities for modification of the site and the site support system to facilitate the safe enclosure phase.

- Modification of auxiliary systems (03.0201) means the activities for reorganisation of site support systems to meet the requirements of the safe enclosure (systems outside the controlled area are the subject of 03.0201).
- Site boundary reconfiguration (03.0202) comprises the activities for physical reconfiguration of the site boundary, modification of access and modification of security systems.
- Construction of temporary enclosures, stores, structural enhancements etc., (03.0203) involves the provision of temporary structures and measures to support site remediation, which are needed to achieve the required status of the safe enclosure.
- Stabilisation of radioactive and hazardous waste pending remediation (03.0204) involves activities for temporary structures and measures to ensure the safety of the removed radioactive materials and hazardous waste removed from the premises prior to safe enclosure, until processing, conditioning and disposal of these materials (this is addressed by Principal Activity 05).
- Facility controlled area hardening, isolation for safe enclosure (03.0205) includes activities for blocking and securing of entrances not used during the safe enclosure and protection of entrances used during the safe enclosure and general activities for conservation, preserving the safety and isolation of the controlled area of the safe enclosure.

Activity Group 03.0300 "Facility entombment" comprises activities for achieving the final entombment status and for institutional control for a defined period following entombment.

- Facility entombment as end state of decommissioning strategy (03.0301) involves activities for completing the designed final state of the facility in the cases of entombment strategies. This item represents only the final activities for realisation of entombment; the activities leading up to entombment are realised as activities within Principal Activities 04 to 11.
- Institutional control and monitoring of the entombment end state (03.0302) involves activities for monitoring of entombment structures, the related site and environment, periodical reporting and other related activities.

Determination of costs and financing for Principal Activity 03

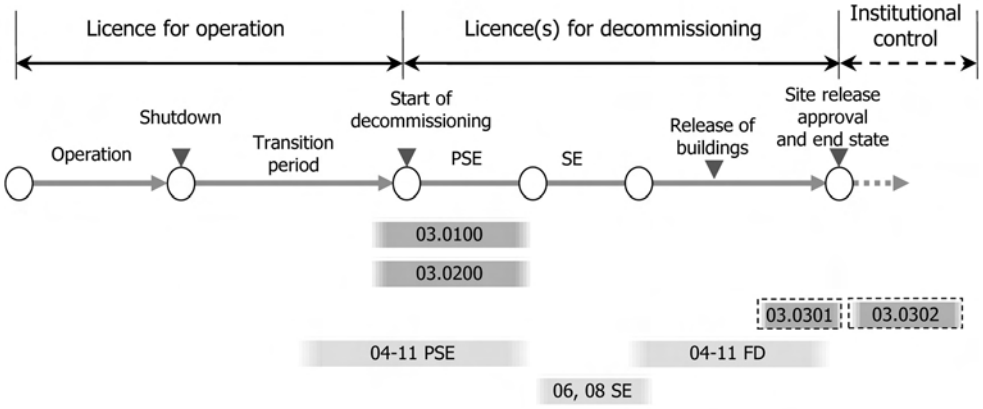
The activities of Principal Activity 03 modify the inventories of systems and structures and partially also the radiological situation. This should be considered when planning the decommissioning activities after the safe enclosure phase.

Depending on the planned extent of safe enclosure, during the period of its preparation other decommissioning activities can be performed, such as full or partial decontamination and dismantling within the auxiliary buildings inside the controlled area, dismantling and demolition of auxiliary buildings and systems outside of the controlled area, partial decontamination, dismantling and demolition of reactor building(s). All these are sub-activities of Principal Activities 04 to 11, which are undertaken in parallel to the sub-activities of Principal Activity 03.

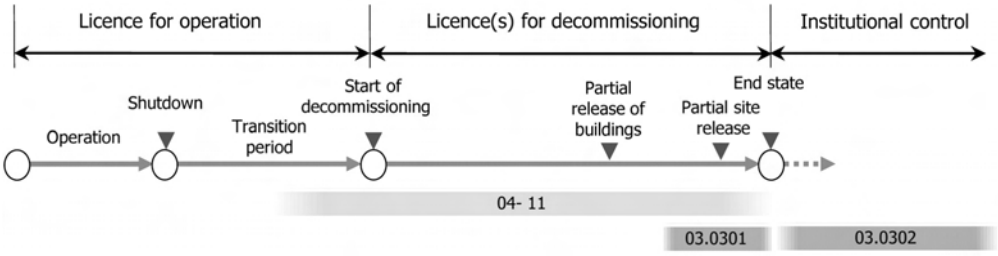
The end state of Principal Activity 03 is the safe enclosure of the facility or, in the case of facility entombment strategies, the entombment end state defined in the decommissioning plan.

The activities of Principal Activity 03 are generally paid from the decommissioning fund. The end state of this Principal Activity involves having the facility ready for safe enclosure in the case of deferred dismantling and the site ready for institutional control in the case of entombment strategies.

Typical schedule for decommissioning activities of Principal Activity 03 for strategies with safe enclosure



Typical schedule for decommissioning activities of Principal Activity 03 for entombment strategies



Legend: FD: final dismantling; PSE: preparation for safe enclosure; SE: safe enclosure.

Notes: The first schedule represents a typical distribution of sub-activities of Principal Activity 03 corresponding to a deferred dismantling strategy and the relationship to other ISDC Main Activity Groups.

The second schedule corresponds to a typical entombment strategy. Prior to entombment, the sub-activities of Principal Activities 01 to 11 are performed to achieve the planned extent of entombment. Entombment activities 03.0101 are performed at the end of the decommissioning project.

In principle, the entombment scenario could be combined also with a safe enclosure strategy. Activities 03.01012 will be performed at the end of final dismantling. Institutional control 03.0302 in both cases is performed after the end of the decommissioning project.

3.3.4 Principal Activity 04: Dismantling activities within the controlled area

04.0100 Procurement of equipment for decontamination and dismantling.

- 04.0101 Procurement of general site-dismantling equipment.
- 04.0102 Procurement of equipment for decontamination of personnel and tools.
- 04.0103 Procurement of special tools for dismantling the reactor systems.
- 04.0104 Procurement of special tools for dismantling in fuel cycle facilities.
- 04.0105 Procurement of special tools for dismantling other components or structures.

04.0200 Preparations and support for dismantling.

- 04.0201 Reconfiguration of existing services, facilities and site to support dismantling.
- 04.0202 Preparation of infrastructure and logistics for dismantling.
- 04.0203 Ongoing radiological characterisation during dismantling.

04.0300 Pre-dismantling decontamination.

- 04.0301 Drainage of remaining systems.
- 04.0302 Removal of sludge and products from remaining systems.
- 04.0303 Decontamination of remaining systems.
- 04.0304 Decontamination of areas in buildings.

04.0400 Removal of materials requiring specific procedures.

- 04.0401 Removal of thermal insulation.
- 04.0402 Removal of asbestos.
- 04.0403 Removal of other hazardous materials.

04.0500 Dismantling of main process systems, structures and components.

- 04.0501 Dismantling of reactor internals.
- 04.0502 Dismantling of reactor vessel and core components.
- 04.0503 Dismantling of other primary loop components.
- 04.0504 Dismantling of main process systems in fuel cycle facilities.
- 04.0505 Dismantling of main process systems in other nuclear facilities.
- 04.0506 Dismantling of external thermal/biological shields.

04.0600 Dismantling of other systems and components.

- 04.0601 Dismantling of auxiliary systems.
- 04.0602 Dismantling of remaining components.

04.0700 Removal of contamination from building structures.

- 04.0701 Removal of embedded elements in buildings.
- 04.0702 Removal of contaminated structures.
- 04.0703 Decontamination of buildings.

04.0800 Removal of contamination from areas outside buildings.

- 04.0801 Removal of underground contaminated pipes and structures.
- 04.0802 Removal of contaminated soil and other contaminated items.

04.0900 Final radioactivity survey for release of buildings.

- 04.0901 Final radioactivity survey of buildings.
- 04.0902 Declassification of buildings.

General features of Principal Activity 04

Principal Activity 04 deals with decontamination and dismantling of systems and structures within the controlled area and with the contaminated items identified at the site outside of the controlled area.

The management of the sub-activities of Principal Activity 04, including daily planning, permits, licensing is addressed by Activity Group 08.0200. Personnel costs covered by Principal Activity 04 relate to the personnel of the working groups performing the activities of Principal Activity 04; including the first level managers (foremen). Detailed ongoing planning of dismantling which involves elaboration of detailed plans to ensure safe, economically effective and timely decontamination and dismantling is also addressed by Activity Group 08.0200.

There may be several possible options for dismantling – one-piece removal, manual or remote segmentation on site for further processing or for direct disposal, etc. Decontamination and dismantling activities involve also all preparatory, supporting and finishing activities. The end state of dismantling activities corresponds to having the one-piece components ready for transport to storage or disposal, segmented components in transport containers ready for transport to storage or disposal or segmented components in transport containers transported to waste processing facilities on site or outside the site boundaries. Records of selected data of performed activities using pre-defined forms may be included in order to develop the feedback to periodical recalculation of cost within the ongoing decommissioning project and for front-end planning and costing of subsequent similar decommissioning cases.

The end state of the Principal Activity 04 corresponds to the buildings being declared ready for free release or demolition; the identified contamination of the site having being removed to the free release level; and materials from dismantling having been transported to on-site workplaces for further processing.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

The activities of Activity Group 04.0100 "Procurement of equipment for decontamination and dismantling" comprise activities for procurement of equipment needed for dismantling, including installation, cold and hot testing, licensing where required and maintenance during the use of equipment. Procurement involves purchase, hire and design and construction of special equipment not available on the market. Remote and/or manually operated equipment and/or systems may be involved. Research and development activities needed for design and construction of special equipment is addressed by Principal Activity 09.

- Procurement of general site-dismantling equipment (04.0101) involves procurement of equipment for general support of dismantling, mostly the lifting and transporting devices. Equipment can be used also for non-active dismantling activities in Principal Activity 07.
- Procurement of equipment for decontamination of personnel and tools (04.0102) involves equipment for support of radiation protection by continuous decontamination of personnel and tools during dismantling.
- Procurement of special tools for dismantling the reactor systems (04.0103) involves equipment and systems needed for remote dismantling of reactor internals and vessels.
- Procurement of special tools for dismantling in fuel cycle facilities (04.0104) involves procurement of specific tools for fuel cycle facilities.

- Procurement of special tools for dismantling other components or structures (04.0105) involves general equipment and tools for decontamination and dismantling, mostly available off the shelf.

The activities of Activity Group 04.0200 "Preparations and support for dismantling" comprise activities for preparing and facilitating of dismantling.

- Reconfiguration of existing services, facilities and site to support dismantling (04.0201) involves reconstruction of auxiliary systems and facilities to the extent needed for supporting dismantling and site boundary reconstruction if needed (e.g. ventilation systems, electricity distribution, transporting and lifting systems).
- Preparation of infrastructure and logistics for dismantling (04.0202) involves preparation of transport routes, containers for local transport of dismantled materials, adaptation of access to the controlled area, connections to electricity and other technical media, temporary storage areas for dismantled materials and other items of infrastructure and logistics for dismantling.
- Ongoing radiological characterisation during dismantling (04.0203) involves activities needed for updating of radiological data which could not be collected in full extent during the facility characterisation in Activity Group 01.0200 and upgraded in Activity Group 02.0400. This item is especially important for fuel cycle facilities and in some cases also for reactor facilities shutdown following an accident. These activities relate to the systems and structures which are accessible only after partial decontamination and/or dismantling undertaken in the context of Principal Activity 04.

The activities of Activity Group 04.0300 "Pre-dismantling decontamination" comprise decontamination activities on systems and structures prior to dismantling for facilitating the dismantling activities and for declassification of generated radioactive waste.

- Drainage of remaining systems (04.0301) involves activities for drainage of open systems not previously drained. This may include residuals identified at the bottom of open systems, requiring special procedures for removal that are not covered by the operational procedures applied during the shutdown activities. Examples are: some open systems of fuel cycle facilities; contaminated fluids in the open systems which require operation different from standard operation procedures; spent fuel pools where the fuel with damaged cladding was stored.
- Removal of sludge and products from remaining systems (04.0302) involves activities for removal of sludge and products (residuals) which require special designed procedures and tools, including remote operations.
- Decontamination of remaining systems (04.0303) involves the decontamination of spent fuel pool and other open systems after drainage of the contaminated fluids. Similarly, decontamination of open systems in fuel cycle facilities involves decontamination of open systems in mechanical and chemical hot cells, decontamination of pools, pits and gutters, where relevant. Decontamination of closed systems and equipment using specific procedures involves procedures and equipment specifically designed for decontamination of systems by autonomous decontamination circuits. Primary and auxiliary systems or selected parts of them may be decontaminated in this way. The activities involve design, construction of the autonomous systems, and on-site preparations for decontamination, system operation during decontamination and demobilisation of the systems after decontamination, including removal of liquid radioactive waste after decontamination to the waste processing facilities.
- Decontamination of areas in buildings (04.0304) involves decontamination of selected areas within the controlled area where the contamination could hamper the dismantling activities due to dose rate or generation of radioactive aerosols.

It may include selected decontamination of outer surfaces of equipment and selected decontamination of building surfaces; both for reactor facilities and for fuel cycle facilities, e.g. areas with spills of radioactive liquids during the operation. Decontamination of steel linings or decontamination of large tanks prior to dismantling is another example of these activities.

Activity Group 04.0400 "Removal of materials requiring specific procedures" involves the removal of specific hazardous materials before dismantling to facilitate the dismantling activities. Specific procedures are implemented.

- Removal of thermal insulation (04.0401) is performed prior to general dismantling in individual premises and systems to facilitate dismantling.
- Removal of asbestos (04.0402) requires specific procedures and safety measures.
- Removal of other hazardous materials (04.0403) covers other hazardous materials identified in systems and structures which should be removed prior to main dismantling activities.

Activity Group 04.0500 "Dismantling of main process systems, structures and components" involves the dismantling of reactor structures and primary components of all types in reactor facilities, main process systems in fuel cycle facilities and in other nuclear facilities and external thermal/biological shields adjacent to reactor systems and main process systems in fuel cycle facilities and in other nuclear facilities.

- Dismantling of reactor internals (04.0501) involves the dismantling of control-rod blades and motors, control rod guide tubes, steam dryer, feedwater sparger ring, core shroud including fixing and fuel channels in channel type reactors. All preparatory, continuous and finishing activities are included.
- Dismantling of reactor vessel and core components (04.0502) involves dismantling of reactor pressure vessel top head, reactor core top head, reactor pressure vessel including support skirt and insulation, graphite structures including graphite supporting structures, moderator core components, etc. A system-oriented approach for dismantling and segmenting according to the subassemblies of reactor system may be used. One-piece removal of the reactor pressure vessel is another option. Remote controlled or underwater cutting arrangements are addressed within this cost item; all related activities should be included, including demobilisation of cutting systems and removal of all secondary (solid and liquid) waste. Dismantling procedures for various types of reactors (pressurised water reactors, boiling water reactors, gas cooled reactors etc.) can be implemented.
- Dismantling of other primary loop components (04.0503) involves dismantling of steam generators, pressurisers, primary pumps, valves and piping, turbine and condenser in boiling water reactors, moderator tank and loops and other components in various types of reactors.
- Dismantling of main process systems in fuel cycle facilities (04.0504) involves dismantling in main process systems in mechanical and chemical hot cells and components such as pools, pits and gutters.
- Dismantling of main process systems in other nuclear facilities (04.0505) involves dismantling of specific main process systems in other nuclear facilities, such as laboratories, accelerators, medical facilities, hot cells and others.
- Dismantling of external thermal/biological shields (04.0506) includes dismantling of any type of shields around main process systems in reactor facilities, fuel cycle facilities and in other nuclear facilities which are not the integral part of reactor

systems or main process systems. Removal of activated parts of concrete reactor shafts is also included in this cost item.

In general, Activity Group 04.0500 also addresses the dismantling of the minor auxiliary systems located in the same premises as the main process system, enabling a room-oriented approach to be reflected in the cost structure, where relevant.

Activity Group 04.0600 "Dismantling of other systems and components" comprises the dismantling of general components from buildings within the controlled area. A room-oriented approach for dismantling is generally implemented, involving the dismantling of components on a room-by-room basis.

- Dismantling of auxiliary systems (04.0601) involves general auxiliary systems in main production buildings and other buildings within the controlled area for all types of nuclear facilities. Examples of components in these systems are small and medium diameter pipes, valves, motors, tanks, hangers, elements of electrical installations, standard ventilation elements and other general equipment. Organising dismantling according to building components (floors and rooms) facilitates the contracting of dismantling activities. Preparatory and finishing activities may be added at room level when applying a room-oriented approach.
- Dismantling of remaining components (04.0602) involves dismantling of contaminated components and materials that can only be dismantled at the end of the dismantling process, when all other components have already been removed. This item also includes the removal of non-contaminated ancillary equipment in support of the decontamination of building surfaces and final release survey.

Activity Group 04.0700 "Removal of contamination from building structures" comprises the removal of contaminated embedded elements, removal of contaminated structures in buildings and removal of all remaining contamination from buildings to the free release level.

- Removal of embedded elements in buildings (04.0701) involves the dismantling of embedded elements according to the facility design and inventory, e.g. pipe lead-through, embedded pipes, hermetic doors and similar components identified in the inventory databases. Dismantling of these items normally requires special tools and procedures and supporting activities. The activities are organised mostly according to a room-oriented approach. On completion of dismantling, additional structural enhancement and/or strengthening of building structure may be required in order to maintain the stability of building structures.
- Removal of contaminated structures (04.0702) involves the dismantling of parts of civil structures with deeper penetration of contamination due to leakages and/or spills during the operation period. These activities are performed after dismantling of all items within the rooms to have access to these areas. In some cases additional structural enhancement is needed after removal of these structures.
- Decontamination of buildings (04.0703) is the removal of remaining contamination of building surfaces by methods of chemical or mechanical decontamination depending on the quality of building surfaces and level of contamination. The activities are typically organised according to the room-oriented approach.

Activity Group 04.0800 "Removal of contamination from areas outside buildings" comprises the removal of contaminated components, structures and other items outside of buildings.

- Removal of underground contaminated pipes and structures (04.0801) involves removal of active underground piping used during operation for transport of

active liquids and removal of contamination from related civil supporting structures.

- Removal of contaminated soil and other contaminated items (04.0802) involves removal of contaminated soils and other contaminated items identified at the site outside of buildings and remediation of underground waters.

Activity Group 04.0900 "Final radioactivity survey for release of buildings" is concerned with achieving the status of free released buildings:

- Final radioactivity survey of buildings (04.0901) relates to the final measurements of all building surfaces for all active buildings required by regulatory authorities as a condition for authorising the release of the buildings. These activities are generally organised according to a room-oriented approach.
- Declassification of buildings (04.0902) involves the production of documentation for free release and the involvement of owner personnel in the process of releasing of buildings.

Determination of costs and financing for Principal Activity 04

Sub-activities of Principal Activity 04 generally have an important fieldwork component, which may be done manually or on a remote–controlled basis. Good inventory data are a prerequisite for accurate costing for these activities. Physical data for systems and structures (such as masses, volumes, materials, decommissioning categories, positions), relevant radiological data (dose rates, contamination, activation, nuclide composition) and careful indexing of inventory data according to the allocation to systems, buildings, floors, rooms, sectors are needed in the facility inventory database in order to organise the dismantling sequence and reporting.

Two basic approaches can be applied to the costing of dismantling activities – a system-oriented approach and a room-oriented approach.

- A system-oriented approach is typically applied for the dismantling of components with complex structures such as reactors and main components of the primary circuit. Dismantling procedures are specific for individual components and normally are organised according to sub-assemblies of the system as the inverse of the construction process. Preparatory and finishing activities and parallel auxiliary activities are added where required. This approach may involve one-piece removal of plant components. Installation of special workshops, such as underwater cutting and similar special equipment, testing, operation, maintenance, surveillance, removal of secondary waste and at the end of the work, the decontamination and removal of special equipment is included here.
- A room-oriented approach involves the organisation of dismantling room by room, by progressive dismantling of all systems within each room. Preparatory and finishing activities are included to the extent necessary for each room.

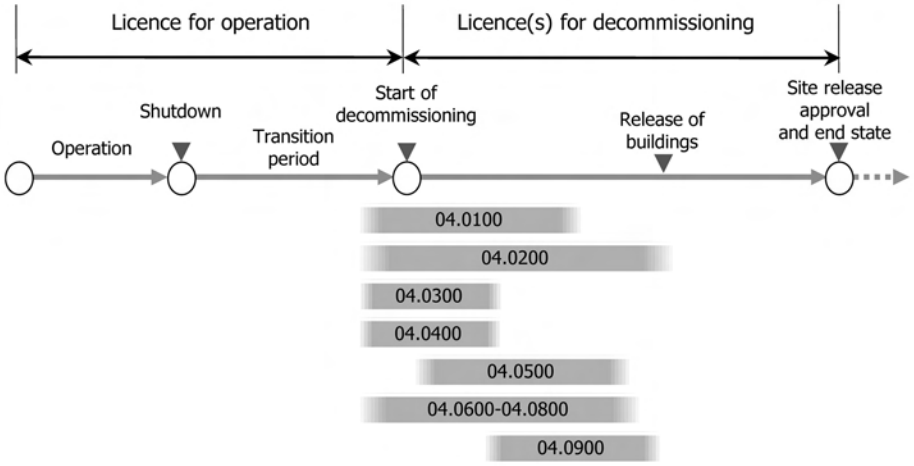
Additional characterisation of facilities for obtaining actual radiological data for detailed planning of decontamination and dismantling is included in activity 04.0203. Verification of the actual radiological situation at the start of dismantling activities is performed as part of the preparatory activities before dismantling.

As regards the costing of personnel involved in the direct performance of decontamination and dismantling activities, the cost of operatives and first level managers of the relevant working groups is normally included. Some personnel may be shared by several working groups and therefore their costs may need to be allocated to different cost items. All other planning, managing and supervising activities are addressed under Activity Group 08.0200.

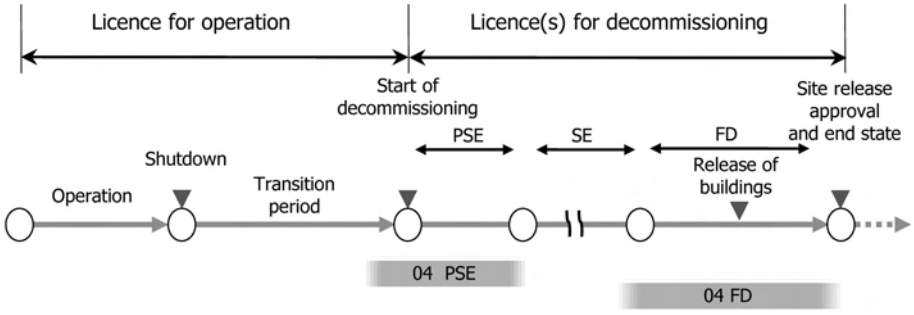
The activities of Principal Activity 04 may be performed by owner personnel or by contractors. The allocation of cost to contractor activities may be done during the detailed planning phase when it is clear which activities will be performed by contractors.

All decommissioning activities of Principal Activity 04 are paid from the decommissioning fund. Some of activities of the Principal Activity 04, especially the sub-activities of 04.0100 to 04.0400 and also dismantling of minor or low contaminated systems, may be performed also under the operational licence during the transition period from the shutdown to obtaining the decommissioning licence [8] based on partial licensing or approvals – see the discussion under Principal Activity 02.

Typical schedule for decommissioning activities of Principal Activity 04 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 04 for deferred dismantling



Legend: FD: final dismantling; PSE: preparation of safe enclosure; SE: safe enclosure.

3.3.5 Principal Activity 05: Waste processing, storage and disposal

05.0100 Waste management system.

- 05.0101 Establishing the waste management system.
- 05.0102 Reconstruction of existing facilities for decommissioning waste management system.
- 05.0103 Procurement of additional equipment for management of historical/legacy waste.

05.0104 Maintenance, surveillance and operational support for waste management system.
05.0105 Demobilisation/decommissioning of waste management system.

05.0200 Management of historical/legacy high-level waste.

05.0201 Characterisation.
05.0202 Retrieval and processing.
05.0203 Final conditioning.
05.0204 Storage.
05.0205 Transport.
05.0206 Disposal.
05.0207 Containers.

05.0300 Management of historical/legacy intermediate-level waste.

05.0301 Characterisation.
05.0302 Retrieval and processing.
05.0303 Final conditioning.
05.0304 Storage.
05.0305 Transport.
05.0306 Disposal.
05.0307 Containers.

05.0400 Management of historical/legacy low-level waste.

05.0401 Characterisation.
05.0402 Retrieval and treatment.
05.0403 Final conditioning.
05.0404 Storage.
05.0405 Transport.
05.0406 Disposal.
05.0407 Containers.

05.0500 Management of historical/legacy very low-level waste.

05.0501 Characterisation.
05.0502 Retrieval, treatment and packaging.
05.0503 Transport.
05.0504 Disposal.

05.0600 Management of historical/legacy exempt waste and materials.

05.0601 Retrieval, treatment and packaging.
05.0602 Clearance measurement of exempt waste and materials.
05.0603 Transport of hazardous waste.
05.0604 Disposal of hazardous waste at dedicated waste dumps.
05.0605 Transport of conventional waste and materials.
05.0606 Disposal of conventional waste at conventional waste dumps.

05.0700 Management of decommissioning high-level waste.

05.0701 Characterisation.
05.0702 Processing.
05.0703 Final conditioning.
05.0704 Storage.
05.0705 Transport.
05.0706 Disposal.
05.0707 Containers.

05.0800 Management of decommissioning intermediate-level waste.

05.0801 Characterisation.
05.0802 Processing.
05.0803 Final conditioning.

05.0804 Storage.
05.0805 Transport.
05.0806 Disposal
05.0807 Containers.

05.0900 Management of decommissioning low-level waste.

05.0901 Characterisation.
05.0902 Processing.
05.0903 Final conditioning.
05.0904 Storage.
05.0905 Transport.
05.0906 Disposal.
05.0907 Containers.

05.1000 Management of decommissioning very low-level waste.

05.1001 Characterisation.
05.1002 Treatment and packaging.
05.1003 Transport.
05.1004 Disposal.

05.1100 Management of decommissioning very short-lived waste.

05.1101 Characterisation.
05.1102 Treatment, storage, handling and packaging.
05.1103 Final management of decommissioning very short-lived waste.

05.1200 Management of decommissioning exempt waste and materials.

05.1201 Treatment and packaging.
05.1202 Clearance measurement of exempt waste and materials.
05.1203 Transport of hazardous waste.
05.1204 Disposal of hazardous waste at dedicated waste dumps.
05.1205 Transport of conventional waste and materials.
05.1206 Disposal of conventional waste at conventional waste dumps.

05.1300 Management of decommissioning waste and materials generated outside controlled areas.

05.1301 Recycling of concrete.
05.1302 Treatment and packaging of hazardous waste.
05.1303 Treatment and recycling of other materials.
05.1304 Transport of hazardous waste.
05.1305 Disposal of hazardous waste at dedicated waste dumps.
05.1306 Transport of conventional waste and materials.
05.1307 Disposal of conventional waste at conventional waste dumps.

General features of Principal Activity 05

Principal Activity 05 deals with all aspects of management of radioactive, hazardous and conventional waste generated during activities of Principal Activities 02 (shutdown activities), 03 (preparation of safe enclosure), 04 (decontamination and dismantling within the controlled area), 07 (dismantling outside of the controlled area and demolition of buildings) and with management of historical/legacy waste. The retrieval of historical/legacy waste is included in Principal Activity 05. The term historical/legacy waste in Principal Activity 05 covers also the remaining operational waste and operational waste generated within Principal Activity 02.

Treatment (including pre-treatment), conditioning, storing, disposal and transports for each type of waste are considered separately. Pre-treatment and treatment generally includes all partial processes prior to conditioning into final disposal packages, such as characterisation and sorting, fragmentation, decontamination, volume reduction,

processing of liquid waste, fixation into various matrixes and other techniques. The cost associated with different types of treatment may be reflected at a fourth hierarchical level, at the discretion of the cost estimator. The extent of treatment should be defined for items on the second level according to the type of waste – both for historical/legacy waste and for decommissioning waste. Transport from the dismantling areas to waste processing areas is included in the dismantling cost.

Depending on the composition of the historical/legacy waste and of the decommissioning waste, the techniques, equipment or facilities for treatment, conditioning, storage, disposal and transport may partially be the same for both categories of waste. Only for those types of historical/legacy waste that do not arise in the decommissioning waste, the waste management system will be extended.

The assumed end state of all types of waste is disposal at repositories for radioactive waste for various levels of waste, repositories for hazardous waste or conventional dumps; and free release or conditional release of reusable materials. Waste management systems for decommissioning projects can be established also as shared systems, which cover several decommissioning projects. Assumptions concerning the decommissioning of the waste management system should be clearly outlined within the boundary conditions for the project and the relevant costs included within Principal Activity 05.

There is a range of options concerning the extent to which costs relating to the operation of waste management systems are included in Principal Activity 05. In certain decommissioning projects the waste management system, covering all types of decommissioning waste, is included; in other cases the waste management system includes only sorting and pre-packaging and transport to other waste management facilities where subsequent activities are contracted as services. There are also cases where the waste management systems are shared between several decommissioning projects or with facilities in operation; and finally cases where the waste management system consists only of sorting, packaging and long term storage.

National legislation or regulations in different countries define the relevant responsibilities for waste treatment, conditioning and disposal. Accordingly, the waste management activities can be performed as the activities of the owner of the facility, activities performed by contractors and activities performed by national agencies for waste management, including waste disposal. In some countries decommissioning, including the waste management, is performed entirely by national agencies. Due to the variability of possible waste management options, Principal Activity 05 has been structured in such a way that waste management costs can be identified independently of whether the activities are performed by owner personnel or are contracted.

As discussed earlier the initial activities concerned with the design of the waste management system for a decommissioning project are included under Activity Group 01.0400. The activities within Principal Activity 05 represent the activities needed to establish the waste management system, operation of the system, decommissioning and/or closure of the system and the logistics of the system.

The assumptions and boundary conditions for the decommissioning project should define the extent and types of waste to be handled including the management of the operational waste from Principal Activity 02 (typically outside the decommissioning project). Assumptions and conditions for a decommissioning project should involve also clear definitions of the waste management system, including:

- overall scheme of the waste management system;
- parameters of individual equipment/techniques/facilities;
- which elements of the waste management scheme are owned/operated by the licensee and which are used as services;

- which elements of the waste management scheme will be procured, installed and licensed;
- what will be the end state of the waste management system, which components will be decommissioned and which will be used for other purposes outside of the evaluated decommissioning project.

Structure of Principal Activity 05

There are many possible approaches concerning how to structure the cost of activities related to waste management. In any waste management system, waste streams can be identified as well as the steps/equipment/techniques for handling of the waste. The ISDC reflects both aspects – streams and techniques. The basic structure is organised according to the IAEA waste classification, as defined in [9] (see box), with the initial items at the Activity Group level addressing common issues related to the establishment and implementation of the waste management system.

According to IAEA classification of waste [9], six classes of waste are used as the basis for the classification scheme:

a) Exempt waste (EW): Waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes. This item may involve also reusable materials.

b) Very short-lived waste (VSLW): Waste that can be stored for decay over a limited period of up to a few years and subsequently cleared from regulatory control according to arrangements approved by the regulatory body, for uncontrolled disposal, use or discharge. This class includes waste containing primarily radionuclides with very short half-lives often used for research and medical purposes.

c) Very low-level waste (VLLW): Waste that does not necessarily meet the criteria of EW, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in near-surface, landfill-type facilities with limited regulatory control. Such landfill-type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer-lived radionuclides in VLLW are generally very limited.

d) Low-level waste (LLW): Waste that is above clearance levels, but with limited amounts of long-lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near-surface facilities. This class covers a very broad range of waste. LLW may include short-lived radionuclides at higher levels of activity concentration, and also long-lived radionuclides, but only at relatively low levels of activity concentration.

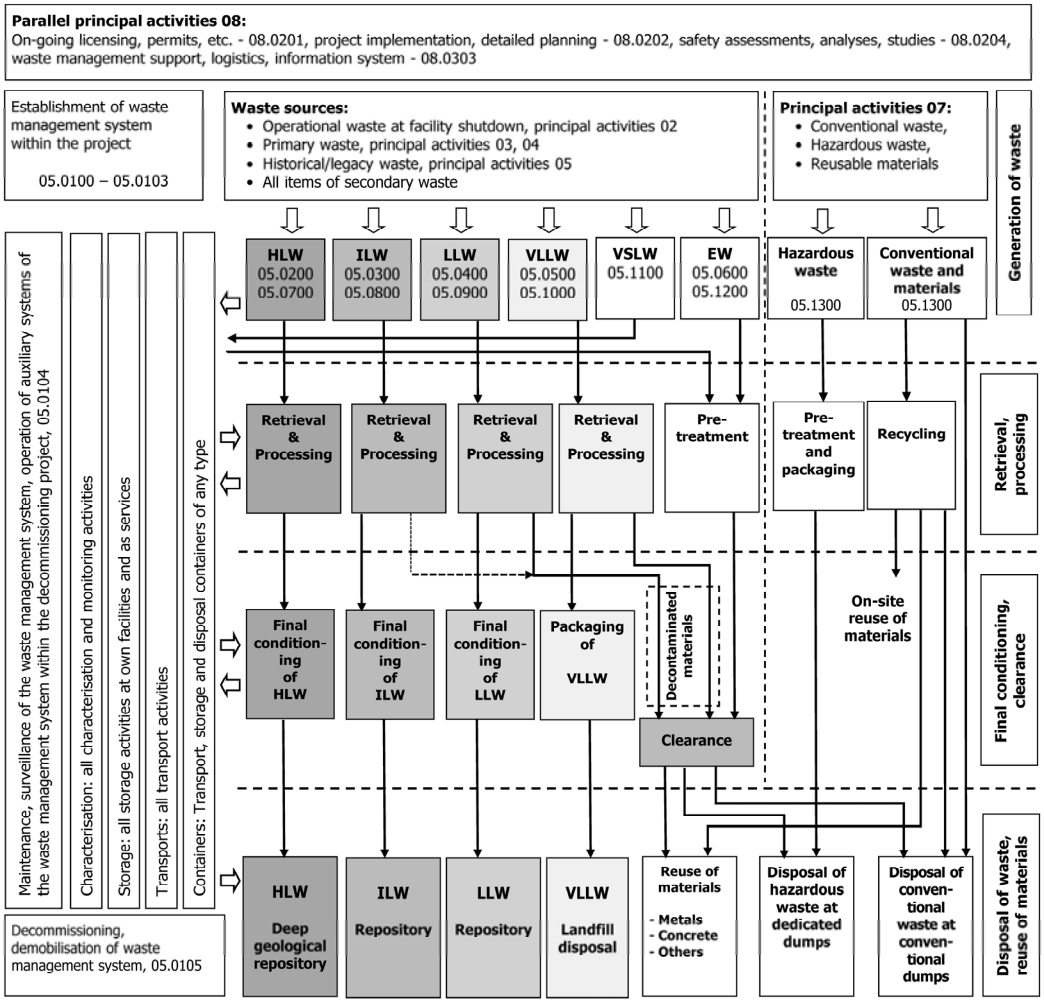
e) Intermediate-level waste (ILW): Waste that, because of its content, particularly of long-lived radionuclides, requires a greater degree of containment and isolation than that provided by near-surface disposal. However, ILW needs no provision, or only limited provision, for heat dissipation during its storage and disposal. ILW may contain long-lived radionuclides, in particular, alpha-emitting radionuclides that will not decay to a level of activity concentration acceptable for near-surface disposal during the time for which institutional controls can be relied upon. Therefore, waste in this class requires disposal at greater depths, of the order of tens of metres to a few hundred metres.

f) High-level waste (HLW): Waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long-lived radionuclides that need to be considered in the design of a disposal facility for such waste. Disposal in deep, stable geological formations usually several hundred metres or more below the surface is the generally recognised option for disposal of HLW.

The main steps considered in waste management are treatment (including pre-treatment), conditioning, storing, and disposal of conditioned/packaged waste or release/reuse of materials. All types of transport between the main steps in waste management must be considered. Characterisation is included in each relevant step. Accordingly, the waste management scheme for any decommissioning project can be

represented by a matrix structure, with waste streams being represented along the vertical axis and waste processing steps/techniques along the horizontal axis. The main indexing of the ISDC at Activity Group level is related to waste types; waste processing steps/techniques are identified at activity level (Level 3). Indexing at discretionary levels, to represent individual waste management techniques, facilitates the retrieval of data according to these techniques. The structure of Principal Activity 05 thus facilitates the retrieval of the data according to the waste types at the second level and according to the waste steps and techniques at the third level and at discretionary fourth levels. The principles of organisation of waste management system in a decommissioning project are presented in the figure below.

Principles of organisation of waste management system in a decommissioning project as implemented into the structure of Principal Activity 05



Description of Activity Groups (Level 2) and Typical Activities (Level 3)

Activity Group 05.0100 "Waste management system" includes the activities for establishing the waste management systems for the decommissioning project. As discussed above, there may be significant variation in the extent to which the costs of various components of waste management systems are included with the cost of a specific decommissioning project, so the individual items of this Activity Group can be used to differing extents. This Activity Group includes the establishment, operation, maintenance and decommissioning of the waste management system dedicated solely

to the decommissioning project and owned/licensed by the licensee of the decommissioning project.

The cost of establishing of waste facilities shared with other licensees and/or operating facilities is not included in Activity Group 05.0100 as these facilities are owned and operated outside of the decommissioning project; instead relevant shared costs for the management of such facilities are addressed within Principal Activity 08. The costs of waste management processes performed in shared facilities are considered as services and are calculated based on unit factors agreed with the owners of the waste management facilities.

Items on the third level can be broken down according to individual waste management techniques and/or equipment.

- Establishing the waste management system (05.0101) involves activities for procurement; design, construction and installation of equipment according to the extent of the waste management system operated as part of the decommissioning project by the owner or by contractors. If the individual techniques are used also for other projects this should be considered in the cost allocated for the decommissioning project by sharing the procurement costs. In cases where waste management techniques external to the project are used as contracted services, the equipment is not procured; the cost for procurement is included within the cost unit factors for individual waste management equipment procured as services. The cost of establishing the waste management system includes installation, cold and hot testing and licensing. Facilities and equipment are mostly available off the shelf, and may include purchase and/or hiring of equipment, facilities; permanent or mobile equipment and facilities may be considered. This cost item includes design, construction and installation of special equipment for special waste management techniques which are not available on the market. Where research and development is needed for design and development of these techniques, these activities are allocated to Principal Activity 09, which item includes the activities for installation, cold and hot testing and licensing.
- Reconstruction of existing facilities for decommissioning waste management system (05.0102) involves activities for reconstruction of existing waste management facilities owned and used by the licensee during the operational phase; reconstructed facilities can be used within the waste management system of the decommissioning project.
- Procurement of additional equipment for management of historical/legacy waste (05.0103) includes procurement, design, construction, installation testing and licensing of additional equipment for managing historical/legacy waste identified in the decommissioning project; it may also include purchase and/or hiring of equipment, facilities; permanent or mobile equipment and facilities. Where research and development activities are needed, these are included within Principal Activity 09.
- Maintenance, surveillance and operational support for waste management system (05.0104) covers the cost of personnel involved in general activities supporting the waste management system. It involves the individuals which do not participate directly in the operation of individual waste management facilities/equipment; personnel required for ongoing maintenance of systems and buildings, for surveillance and for (permanent) operation of auxiliary systems such as ventilation, lightning, delivery of electricity, water, gas, and specific materials of the waste management systems operated by the licensee. The cost for operation of auxiliary systems should be included; but not personnel involved in operation of individual waste management techniques; nor the cost

of operation and the cost for specific materials and expenses for individual waste management techniques.

- Demobilisation/decommissioning of waste management system (05.0105) involves activities for decontamination, dismantling and other relevant activities for decommissioning of individual waste management techniques after finishing of the decommissioning project.

Activity Group 05.0200 "Management of historical/legacy high-level waste", Activity Group 05.0300 "Management of historical/legacy intermediate-level waste" and Activity Group 05.0400 "Management of historical/legacy low-level waste" have the same structure at the third level involving characterisation, retrieval and processing, final conditioning, storage, transport, disposal and procurement of containers (all types for transporting, storage and disposal); all items are identified for each type of historical/legacy waste (HLW, ILW, LLW etc.).

Ongoing characterisation activities are included in each step. Retrieval and processing may include several stages and special equipment may be needed; procurement, design, construction, installation, licensing is included; manual and remote operations (for HLW) are considered. Refer to the discussion above in the case of shared used of waste processing facilities.

Activity Group 05.0500 "Management of historical/legacy very low-level waste" is concerned with the following main steps: characterisation (including final monitoring of disposal packages); retrieval, treatment (several stages may be involved) and packaging (simple package forms are assumed such as plastic bags); transport and disposal of very low-level waste. The use of standard equipment and procedures is anticipated. Clearance of declassified very low-level waste is addressed in Activity Group 05.0700.

Activity Group 05.0600 "Management of historical/legacy exempt waste and materials" comprises six main steps: retrieval, treatment and packaging of waste and materials, clearance measurement of waste and materials, transport of hazardous waste, disposal of hazardous waste at dedicated waste dumps, transport of conventional EW waste and disposal of conventional waste at conventional dumps.

Activity Group 05.0700 "Management of decommissioning high-level waste", Activity Group 05.0800 "Management of decommissioning intermediate-level waste", Activity Group 05.0900 "Management of decommissioning low-level waste" all have the same structure at activity level – involving characterisation, processing, final conditioning, storage, transport, disposal and containers (all types for transporting, storage and disposal); all items are identified for each type of historical/legacy waste (HLW, ILW and LLW).

Ongoing characterisation activities are included in each step. Processing may include several stages, special equipment may be needed; procurement, design, construction, installation, licensing is included; manual and remote operations (for HLW) are addressed within this Activity Group. Refer to the discussion above in the case of shared used of waste processing facilities.

Activity Group 05.1000 "Management of decommissioning very low-level waste" addresses the following main steps: characterisation (including final monitoring of disposal packages); treatment (several stages may be involved) and packaging (simple package forms are assumed such as plastic bags); transport and disposal of very low-level waste. The use of standard equipment and procedures is anticipated.

Activity Group 05.1100 "Management of decommissioning very short-lived waste" addresses three main steps: characterisation, treatment (several stages may be involved), and final management of waste (including any activities for final management of this waste). Materials subject to clearance are addressed by 05.1200.

Activity Group 05.1200 "Management of decommissioning exempt waste and materials" addresses six main waste steps: treatment and packaging of waste and materials,

clearance measurement of waste and materials, transport of hazardous waste, disposal of hazardous waste at dedicated waste dumps, transport of conventional waste and disposal of conventional waste at conventional dumps.

Activity Group 05.1300 "Management of decommissioning waste and materials generated outside controlled areas" are related to decommissioning waste generated during conventional dismantling and demolition and site restoration within Principal Activity 07. Seven main steps are identified: recycling of concrete from demolition, treatment and packaging of hazardous materials, treatment and recycling of other materials, transport of hazardous decommissioning waste, disposal of hazardous waste at dedicated waste dumps, transport of conventional decommissioning waste and disposal of conventional waste at conventional waste disposal facilities.

Determination of costs and financing for Principal Activity 05

- Procurement, ownership, sharing of equipment/facilities and/or providing services in decommissioning waste management

As discussed above, there is a range of options for assigning the costs of waste management systems to individual decommissioning projects; only in limited cases are the full costs of a waste management system assigned to an individual decommissioning project. More typically, the waste management systems are shared systems for an entire nuclear site or involve national facilities off site. There will usually also be only one (or a few) waste disposal per country. In these cases, sharing of facilities of waste management systems means that individual equipment/techniques are used partially for several decommissioning projects. Several typical models can be used in management of decommissioning waste, as discussed below.

Ownership of the waste management system except disposal facilities

Waste management equipment/facilities may be owned by the decommissioning licensee (e.g. in cases of larger decommissioning projects) or facilities outside of the decommissioning project may be used (e.g. in the case of small decommissioning projects). The owner is responsible for the procurement and establishment of the waste management system, including installation, cold and hot testing, licensing the operation of the waste management system and its maintenance. At the end of the decommissioning project, the owner is responsible for termination of operation and decommissioning of the waste management system, where applicable. In this case, all costs for establishment, operation and decommissioning are included within the cost of the decommissioning project.

In certain cases, the waste management system may be used in other projects after completion of the decommissioning project or there may be parallel use of the waste management system for other purposes during the evaluated decommissioning project. In such cases, the calculation basis is the proportionate cost for procurement, establishment, licensing and all other activities required to make the equipment/facility operational, the proportionate cost for its decommissioning, together with the cost of operation of the equipment/facility during its use for the evaluated decommissioning project. A proportionate cost means the ratio of the volume of the waste type processed at the equipment/facility to total life cycle operational capacity of the equipment/facility. Use of unit factors for individual equipment/techniques is usually applied in these cases.

Partial ownership of waste management system

This addresses the situation where only a part of the waste management system is procured, installed and licensed by the licensee for use in the decommissioning project. This typically involves the first stages of waste management such as sorting, fragmentation, monitoring, some treatment techniques, temporary packaging, storing and transports. Other elements of

the waste management system needed for the decommissioning project are contracted as services. This is mostly the case for small decommissioning projects.

The cost of those elements of the waste management system that are part of the decommissioning project are evaluated to their full extent starting from procurement, installation, operation until decommissioning of the system. The cost for external services is evaluated based on contracted unit factors.

Disposal facilities

Disposal facilities are normally state-owned. The cost of disposal is calculated on the basis of unit factors for individual types of conditioned waste and depends of the type of disposal facility. Unit factors apply to all aspects of the lifecycle of the disposal facility, starting from feasibility studies for facilities, siting, installation, licensing, operation, closure and institutional control, where applicable.

- Costing of waste management activities

The procurement, installation, licensing and decommissioning of equipment/facilities is fully included in the cost evaluation in those cases where the equipment/facility is used and owned by the licensee as part of the decommissioning project. Care should be taken not to double count the cost of procurement, i.e. that this is not included within the operational unit factors for the equipment/technique as well as being treated as a separate cost.

When using a waste management equipment/facility outside of the decommissioning project, unit factors are used. The extent of unit factors may vary – from one overall cost unit factor for a normalised unit of the processed waste (cubic metre, tonne, piece etc.) up to a spectrum of unit factors involving manpower unit factors, cost unit factors related to labour, investment and expenses, unit factors for consumption of electricity, gas, cement, bitumen and other operational technical media and materials.

- Phasing of waste management activities

The same waste management activities can be repeated in a decommissioning project over several phases, depending on the strategy selected and depending on the WBS of the decommissioning project. Costs for individual equipment/techniques at the lowest numbered level defined for the project are allocated to relevant items of the WBS and are summed at the lowest numbered levels for the decommissioning project. For identification of individual sub phases of the same activities in the WBS of the decommissioning project, additional numbering at levels lower than the third level may be used at the discretion of the cost estimator.

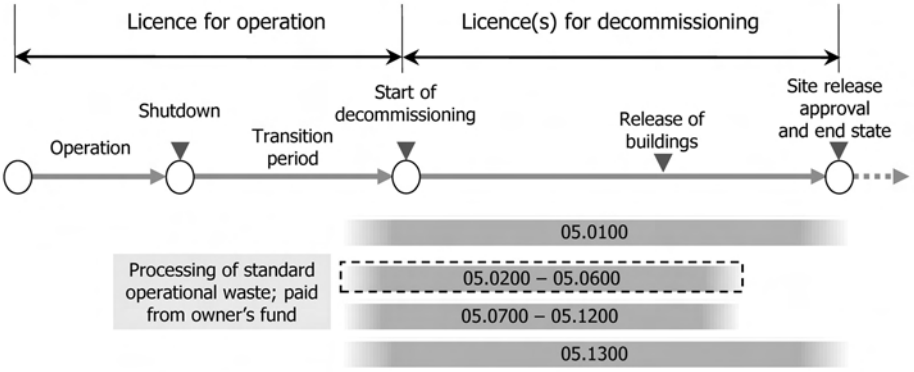
Historical/legacy waste *vs.* decommissioning waste

Historical/legacy waste from operation and decommissioning waste may be processed in the common waste management system for the specific waste type (HLW, ILW, LLW, VLLW etc.). Costs are related to volumes of individual streams of waste.

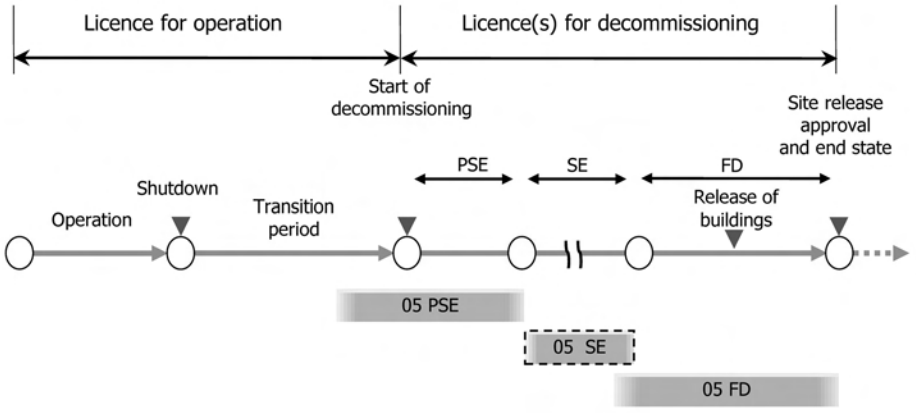
Funding of waste management activities

Waste management activities related to decommissioning waste, including the design, construction (or reconstruction), procurement, installation of waste management facilities and techniques are paid from decommissioning fund. Waste management activities for legacy/historical waste are normally paid from owners' funds. This situation is country dependent. Special cases may be identified for small nuclear facilities such as research reactors, which are generally state-owned. Another non-standard situation may be identified for post-accidental decommissioning projects or in the decommissioning cases related to political decisions for shutdown. Funding of waste management activities other than related to decommissioning waste should be clearly defined in the assumptions and boundary conditions.

Typical schedule for decommissioning activities of Principal Activity 05 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 05 for deferred dismantling



Legend: FD: final dismantling; PSE: preparation of safe enclosure; SE: safe enclosure.

3.3.6 Principal Activity 06: Site infrastructure and operation

06.0100 Site security and surveillance.

- 06.0101 Procurement of general security equipment.
- 06.0102 Operation and maintenance of automated access control systems, monitoring systems and alarms.
- 06.0103 Security fencing and protection of remaining entrances against trespassing.
- 06.0104 Deployment of guards/security forces.

06.0200 Site operation and maintenance.

- 06.0201 Inspection and maintenance of buildings and systems.
- 06.0202 Site upkeep activities.

06.0300 Operation of support systems.

- 06.0301 Electricity supply systems.
- 06.0302 Ventilation systems.
- 06.0303 Heating, steam and lighting systems.

06.0304 Water supply systems.
06.0305 Sewage/waste water systems.
06.0306 Compressed air/nitrogen systems.
06.0307 Other systems.

06.0400 Radiation and environmental safety monitoring.

06.0401 Procurement and maintenance of equipment for radiation protection and environmental monitoring.
06.0402 Radiation protection and monitoring.
06.0403 Environmental protection and radiation environmental monitoring.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

Activity Group 06.0100 "Site security and surveillance" is concerned with procurement of equipment, operation of security and surveillance systems, and security personnel:

- Procurement of general security equipment (06.0101).
- Operation and maintenance of automated access control systems, monitoring systems and alarms (06.0102).
- Security fencing and protection of remaining entrances against trespassing (06.0103).
- Deployment of guards/security forces (06.0104).

Items 06.0101 to 06.0103 involve operation of systems and personnel needed for operation, monitoring, and maintenance of the systems. Item 06.0104 relates to the provision of security personnel.

Activity Group 06.0200 "Site operation and maintenance" comprises:

- Inspection and maintenance of buildings and systems (06.0201) which is periodical inspection and maintenance to the extent defined by operational procedures for individual systems. This item includes periodic inspection and maintenance of buildings and barriers to prevent the leakage of radioactivity, capital maintenance of buildings, periodical inspection and maintenance of systems to be decommissioned, periodical inspection and maintenance of buildings and systems and capital maintenance of buildings during decommissioning and during the safe enclosure. Inspection and maintenance of operating auxiliary systems is not included; these activities are included within Activity Group 06.0300; and
- Site upkeep activities (06.0202), involving periodical maintenance of the site.

Activity Group 06.0300 "Operation of support systems" is concerned with the operation of the utility systems:

- Electricity supply systems (06.0301).
- Ventilation systems (06.0302).
- Heating, steam and lighting system (06.0303).
- Water supply systems (06.0304).
- Sewage/waste water systems (06.0305).
- Compressed air/nitrogen systems (06.0306).
- Other systems (06.0307).

Modification of existing auxiliary support systems at the start of decommissioning is addressed by sub-activity 04.0201; Activity Group 06.0300 is concerned with the

operation of these systems and continuous modification of these systems during decommissioning.

The cost of operation (personnel for operation and maintenance, electricity etc.) of the systems should be included; the cost for technical media delivered by the systems (electricity or water, as an example) may be included here or allocated to individual decommissioning activities; the adopted approach should be stated in the costing approach.

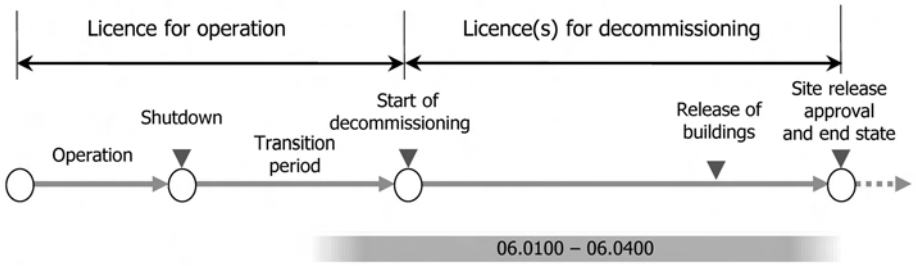
Activity Group 06.0400 "Radiation and environmental safety monitoring" is concerned with the procurement and operation of systems for radiological protection and monitoring:

- Procurement and maintenance of equipment for radiation protection and environmental monitoring (06.0401).
- Radiation protection and monitoring (06.0402).
- Environmental protection and radiation environmental monitoring (06.0403).

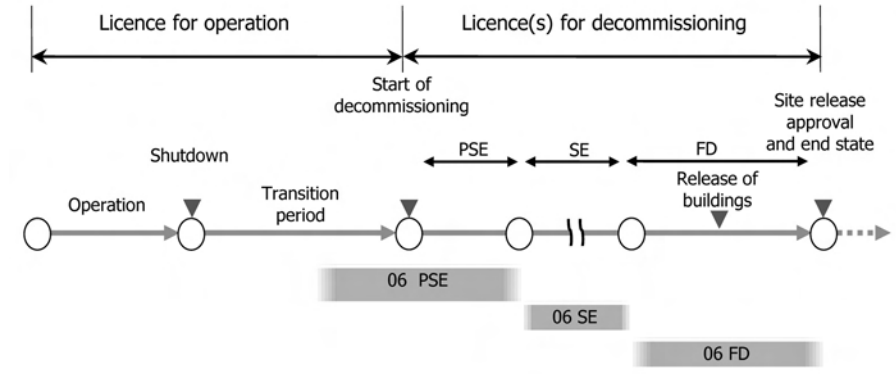
Determination of costs and financing for Principal Activity 06

Principal Activity 06 is concerned with operation of the site and supporting services. The extent of relevant activities during different project phases may vary considerably, e.g. ranging from a maximal level during the dismantling period to a minimal level during safe enclosure. Optimisation of the use of site services may be achieved by subdividing of the main phases into segments to match the extent of activities of Principal Activity 06.

Typical schedule for decommissioning activities of Principal Activity 06 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 06 for deferred dismantling



Legend: FD: final dismantling; PSE: preparation of safe enclosure; SE: safe enclosure.

3.3.7 Principal Activity 07: Conventional dismantling, demolition and site restoration

07.0100 Procurement of equipment for conventional dismantling and demolition.

- 07.0101 Procurement of equipment for conventional dismantling and demolition.

07.0200 Dismantling of systems and building components outside the controlled area.

- 07.0201 Electricity generating system.
- 07.0202 Cooling system components.
- 07.0203 Other auxiliary systems.

07.0300 Demolition of buildings and structures.

- 07.0301 Demolition of buildings and structures from the formerly controlled area.
- 07.0302 Demolition of buildings and structures outside the controlled area.
- 07.0303 Dismantling of the stack.

07.0400 Final cleanup, landscaping and refurbishment.

- 07.0401 Earthworks, landworks.
- 07.0402 Landscaping and other site finishing activities.
- 07.0403 Refurbishment of buildings.

07.0500 Final radioactivity survey of site.

- 07.0501 Final survey.
- 07.0502 Independent verification of the final survey.

07.0600 Perpetuity funding/surveillance for limited or restricted release of property.

- 07.0601 Routine maintenance.
- 07.0602 Surveillance and monitoring.

General features of Principal Activity 07

Principal Activity 07 involves: procurement activities for conventional dismantling in buildings outside of the controlled area and conventional demolition of buildings; landscaping and final survey of the site. Management of waste from these activities is addressed within Principal Activity 05.

The decommissioning strategy may involve different end states of buildings, including:

- No demolition.
- Demolition to a pre-defined level (e.g. -1 m).
- Full removal of civil structures.

The site may be free released from regulatory control or may be released with restrictions, which impose some additional activities for a defined period.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

Activity Group 07.0100 "Procurement of equipment for conventional dismantling and demolition" is concerned with:

- Procurement of equipment for conventional dismantling and demolition (07.0101), i.e. by purchase or hiring. Maintenance of equipment is included.

Activity Group 07.0200 "Dismantling of systems and building components outside the controlled area" involves dismantling tasks in buildings outside the controlled area; the systems are grouped as follows:

- Electricity generating system (07.0201).
- Cooling system components (07.0202).
- Other auxiliary systems (07.0203).

Activity Group 07.0300 "Demolition of buildings and structures" comprises:

- Demolition of buildings and structures from the formerly controlled area (07.0301), i.e. after free release activities in Principal Activity 04.
- Demolition of buildings and structures outside the controlled area (07.0302).
- Dismantling of the stack (07.0303).

The level of demolition is defined in the decommissioning plan.

Activity Group 07.0400 "Final cleanup, landscaping and refurbishment" comprises:

- Earthworks, landworks (07.0401).
- Landscaping and other site finishing activities (07.0402); the aim of both items is to achieve the final status of the facility according to the definitions of the end state.
- Refurbishment of buildings (07.0403) involves activities for facilitating the reuse of buildings.

Activities Group 07.0500 "Final radioactivity survey of site" is concerned with activities leading to the free release of the site, including:

- Final survey (07.0501).
- Independent verification of the final survey (07.0502).

Activity Group 07.0600 "Perpetuity funding/surveillance for limited or restricted release of property" involves activities applying to the situation where the site is being released on a conditional basis, i.e. with restrictions and some activities are to be performed during a defined period. Relevant activities include:

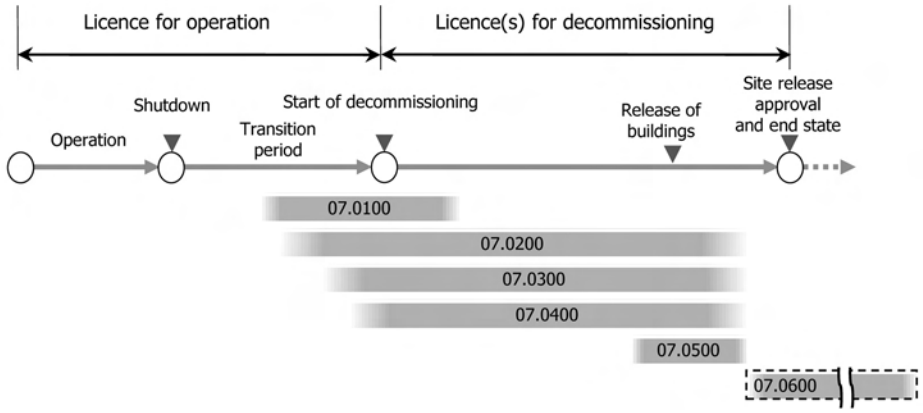
- Routine maintenance (07.0601).
- Surveillance and monitoring (07.0602) of the site and remaining structures.

Determination of costs and financing for Principal Activity 07

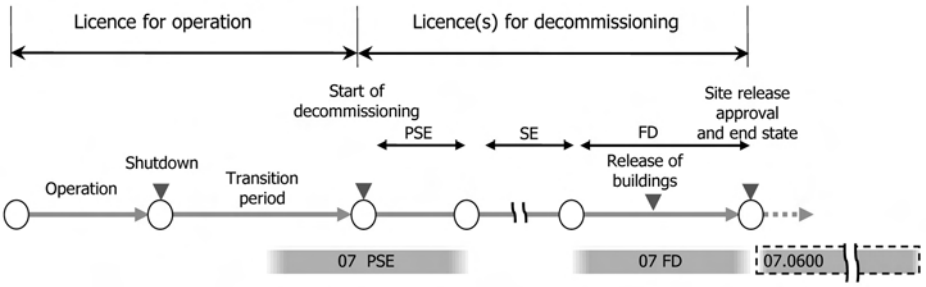
Activities of 07.0200 and 07.0300 are typical activities related to the inventory database. 07.0400 activities are evaluated individually in decommissioning projects.

Funding for these activities may be provided from special funds which are used during the period of restricted use of the site.

Typical schedule for decommissioning activities of Principal Activity 07 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 07 for deferred dismantling



Legend: FD: final dismantling; PSE: preparation of safe enclosure; SE: safe enclosure.

3.3.8 Principal Activity 08: Project management, engineering and support

08.0100 Mobilisation and preparatory work.

- 08.0101 Mobilisation of personnel.
- 08.0102 Establishment of general supporting infrastructure for a decommissioning project.

08.0200 Project management.

- 08.0201 Core management group.
- 08.0202 Project implementation planning, detailed ongoing planning.
- 08.0203 Scheduling and cost control.
- 08.0204 Safety and environmental analysis, ongoing studies.
- 08.0205 Quality assurance and quality surveillance.
- 08.0206 General administration and accounting.
- 08.0207 Public relations and stakeholder involvement.

08.0300 Support services.

- 08.0301 Engineering support.
- 08.0302 Information system and computer support.
- 08.0303 Waste management support.
- 08.0304 Decommissioning support including chemistry, decontamination.
- 08.0305 Personnel management and training.
- 08.0306 Documentation and records control.
- 08.0307 Procurement, warehousing, and materials handling.
- 08.0308 Housing, office equipment, support services.

08.0400 Health and safety.

08.0401 Health physics.
08.0402 Industrial safety.

08.0500 Demobilisation.

08.0501 Demobilisation of project infrastructure for decommissioning.
08.0502 Demobilisation of personnel.

08.0600 Mobilisation and preparatory work by contractors (if needed).

08.0601 Mobilisation of personnel.
08.0602 Establishment of general supporting infrastructure for decommissioning project.

08.0700 Project management by contractors (if needed).

08.0701 Core management group.
08.0702 Project implementation planning, detailed ongoing planning.
08.0703 Scheduling and cost control.
08.0704 Safety and environmental analysis, ongoing studies.
08.0705 Quality assurance and quality surveillance.
08.0706 General administration and accounting.
08.0707 Public relations and stakeholders involvement.

08.0800 Support services by contractors (if needed).

08.0801 Engineering support.
08.0802 Information system and computer support.
08.0803 Waste management support.
08.0804 Decommissioning support including chemistry, decontamination.
08.0805 Personal management and training.
08.0806 Documentation and records control.
08.0807 Procurement, warehousing, and materials handling.
08.0808 Housing, office equipment, support services.

08.0900 Health and safety by contractors (if needed).

08.0901 Health physics.
08.0902 Industrial safety.

08.1000 Demobilisation by contractors (if needed).

08.1001 Demobilisation of project infrastructure for decommissioning.
08.1002 Demobilisation of personnel.

General features of Principal Activity 08

Principal Activity 08 is concerned with activities related to the management, engineering, safety, and general or specialised support for a decommissioning project. Mobilisation and demobilisation activities prior to and after the decommissioning project are involved. Site support activities are addressed within Principal Activity 06. Individual items of Principal Activity 08 relate mainly to the main management team and to specialised support teams.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

Activity Group 08.0100 "Mobilisation and preparatory work" is concerned with mobilisation activities at the start of a decommissioning project:

- Mobilisation of personnel (08.0101) with the aim to ensure the qualified personnel be available; and

- Establishment of general supporting infrastructure for a decommissioning project (08.0102) to install temporary facilities and services; the item does not include preparation for dismantling in 04.0100, 04.0200 and 05.0100. Modification of existing support systems is addressed here; operation of systems during decommissioning is addressed within 06.0300.

Activity Group 08.0200 "Project management" involves core project management activities, including the development of project implementation plans. Partial licensing for installation of facilities for waste management or other facilities related to the decommissioning project is included here in relevant items on the third level.

- Core management group (08.0201) refers to the core managing team. It includes the project manager and decision making individuals, management of relations with contractor(s), top level management of decommissioning activities, and administration of the core management group.
- Project implementation planning, detailed ongoing planning (08.0202) involves the activities of the team responsible for implementation planning and for detailed planning of activities during decommissioning.
- Scheduling and cost control (08.0203) refers to the team responsible for managing decommissioning schedules and cost control.
- Safety and environmental analysis, ongoing studies (08.0204) involves the undertaking of studies for ongoing decontamination, dismantling and for waste management (as required by the decommissioning licence).
- Quality assurance and quality surveillance (08.0205) refers to the team responsible for control of the QA of the decommissioning project according to the quality criteria defined at the outset.
- General administration and accounting (08.0206) refers to the administration and accounting team for the project.
- Public relations and stakeholder involvement (08.0207) refers to the activities related to public and stakeholder involvement.

Activity Group 08.0300 "Support services" involves the following activities:

- Engineering support (08.0301) refers to the team providing specialised engineering support of the decommissioning project, support for nuclear aspects, environment and licensing.
- Information system and computer support (08.0302) refers to the team responsible for the operation of the facility information system and general computer support.
- Waste management support (08.0303) refers to the team responsible for managing the operation of the waste management system, for providing specialised support on waste management, for operation of the waste management information and logistic systems, and for interfacing with the waste management activities of contractors.
- Decommissioning support including chemistry, decontamination (08.0304) refers to the team responsible for managing decontamination activities, including management of specialist personnel for decontamination, and operation of specialised sanitary facilities including the personnel.
- Personnel management and training (08.0305) refers to the team responsible for organising and performing all types of training – general, specialised, periodical retraining.

- Documentation and records control (08.0306) refers to the team responsible for record keeping activities.
- Procurement, warehousing, and materials handling (08.0307) refers to the team responsible for procurement of equipment and materials.
- Housing, office equipment, support services (08.0308) refers to the personnel and operation of specialised facilities for these purposes.

Activity Group 08.0400 "Health and safety" comprises:

- Health physics (08.0401) – the team responsible for supporting the management and performance of decommissioning activities and operation of specialised health physics facilities;
- Industrial safety (08.0402) refers to the team responsible for operation of specialised facilities.

Activity Group 08.0500 "Demobilisation" comprises:

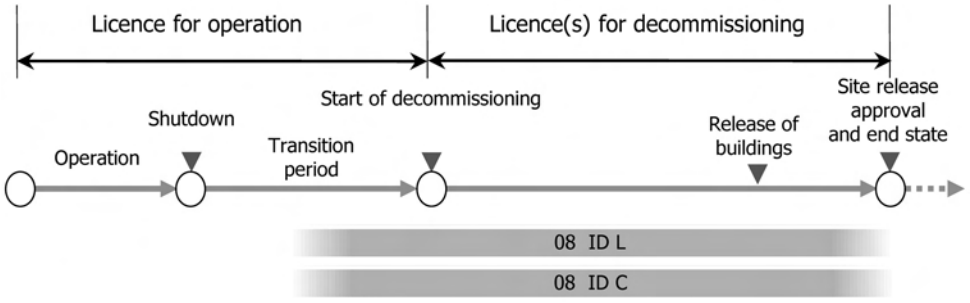
- Demobilisation of project infrastructure for decommissioning (08.0501), i.e. removal of temporary facilities and services at the end of the decommissioning project;
- Demobilisation of personnel (08.0502).

In order to be able to effectively differentiate costs for management activities which are undertaken by contractor, rather than owner personnel, identical segments for contractors are defined as Activity Groups 08.0600 to 08.1000. Appropriate personnel rates need to be used in each case.

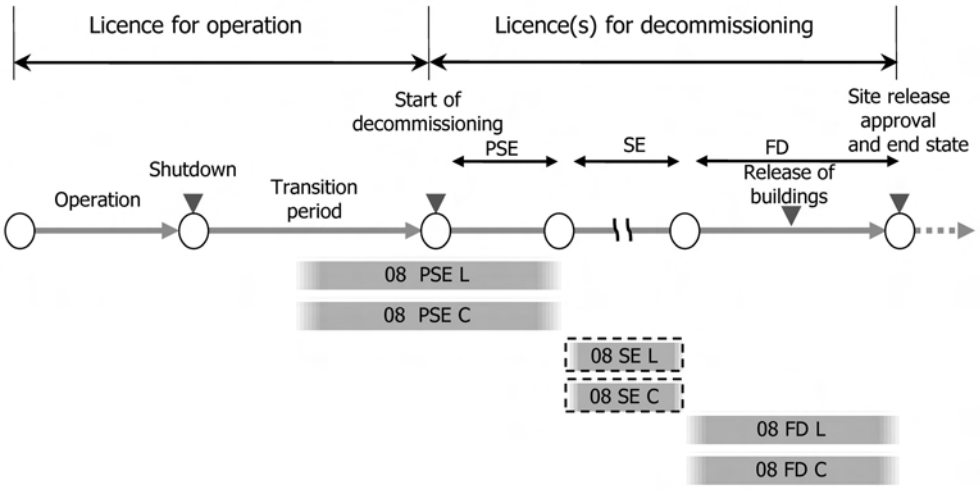
Determination of costs and financing for Principal Activity 08

The extent of the sub-activities of Principal Activity 08 within individual phases can be very different, e.g. a high level of management activity may be anticipated during the dismantling period whereas this will be much less during safe enclosure. It may be important to differentiate the extent of such activities within individual project phases, requiring the use of additional user-defined hierarchical levels of the cost structure.

Typical schedule for decommissioning activities of Principal Activity 08 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 08 for deferred dismantling



Legend: C: contractor; FD: final dismantling; ID: immediate dismantling; L: licensee; PSE: preparation of safe enclosure; SE: safe enclosure.

3.3.9 Principal Activity 09: Research and development

09.0100 Research and development of equipment, techniques and procedures.

- 09.0101 Equipment, techniques and procedures for characterisation.
- 09.0102 Equipment, techniques and procedures for decontamination.
- 09.0103 Equipment, techniques and procedures for dismantling.
- 09.0104 Equipment, techniques and procedures for waste management.
- 09.0105 Other research and development activities.

09.0200 Simulation of complicated works.

- 09.0201 Physical mock-ups and training.
- 09.0202 Test or demonstration programmes.
- 09.0203 Computer simulations, visualisations and 3D modelling.
- 09.0204 Other activities.

General features of Principal Activity 09

Principal Activity 09 involves the activities of research and development in the case where new specific data are needed for design and construction of special equipment for characterisation, decontamination, dismantling waste management and for safety aspects; for development of new procedures and techniques.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

Activity Group 09.0100 "Research and development of equipment, techniques and procedures" comprises:

- Equipment, techniques and procedures for characterisation (09.0101).
- Equipment, techniques and procedures for decontamination (09.0102).
- Equipment, techniques and procedures for dismantling (09.0103).
- Equipment, techniques and procedures for waste management (09.0104).
- Other research and development activities (09.0105).

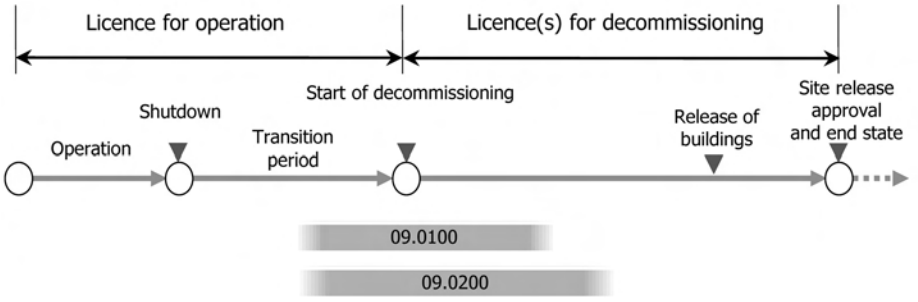
Activity Group 09.0200 "Simulation of complicated works" comprises:

- Physical mock-ups and training (09.0201).
- Test or demonstration programmes (09.0202).
- Computer simulations, visualisations and 3D modelling (09.0203).
- Other activities (09.0204).

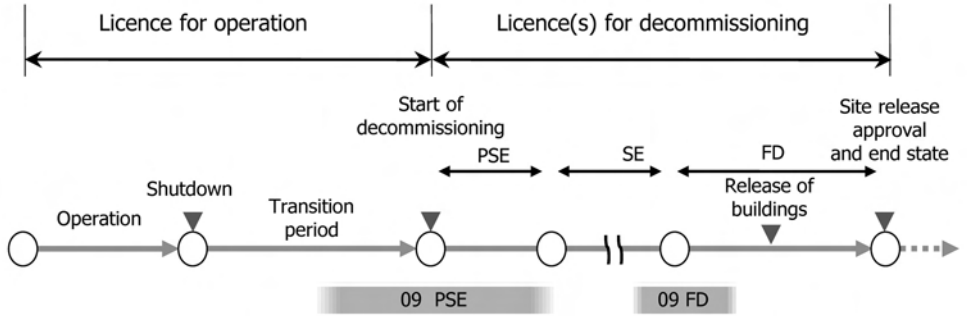
Determination of costs and financing for Principal Activity 09

Research and development activities are defined individually for each decommissioning project. Research and development activities may play an important role especially in decommissioning projects involving old facilities being dismantled long after shutdown, decommissioning of facilities following an accident, facilities with damaged spent fuel, and those having large amounts of historical and legacy waste in storage in the facility. In these cases, research and development may be needed to determine the precise status of the facility, for identifying or adapting solutions for characterisation, decontamination, dismantling, and waste management and for ensuring the safety of the post-accidental situations of systems and structures and in the event of using new or adapted procedures. The cost for research and development in these cases may be significant. Assumptions and boundary conditions should identify the needs for these activities.

Typical schedule for decommissioning activities of Principal Activity 09 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 09 for deferred dismantling



Legend: FD: final dismantling; PSE: preparation of safe enclosure; SE: safe enclosure.

3.3.10 Principal Activity 10: Fuel and nuclear material

10.0100 Removal of fuel or nuclear material from facility to be decommissioned.

- 10.0101 Transfer of fuel or nuclear material to external storage or to treatment facilities.
- 10.0102 Transfer of fuel or nuclear material to dedicated buffer store.

10.0200 Dedicated buffer storage for fuel and/or nuclear material.

- 10.0201 Construction of buffer storage.
- 10.0202 Operation of buffer storage.
- 10.0203 Transfer of fuel and/or nuclear material away from the buffer storage.

10.0300 Decommissioning of buffer storage.

- 10.0301 Decommissioning of buffer storage.
- 10.0302 Management of waste.

General features of Principal Activity 10

Principal Activity 10 "Fuel and nuclear material" is concerned with all activities defined within the decommissioning project for management of spent fuel and nuclear materials. The end state of this Principal Activity requires that the site be free of the spent fuel and/or any nuclear materials. Storage on site, where relevant, is included. Any treatment of the spent fuel including disposal is outside the scope of Principal Activity 10. Decommissioning of the on-site buffer storage facility, where relevant, is included. Buffer storage is included for those cases where the temporary storage in the reactor building is not available for whatever reason. Decommissioning of research reactors and/or specific NPP cases may require buffer fuel storage. For standard NPP decommissioning projects Principal Activity 10 relates to transport of the spent fuel out of the facility after the cooling down period.

The management of the spent fuel and nuclear materials after their transport from the site is typically the subject of back-end fuel cycle programmes, rather than being seen as a decommissioning activity.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

Activity Group 10.0100 "Removal of fuel or nuclear material from facility to be decommissioned" comprises:

- Transfer of fuel or nuclear material to external storage or to treatment facilities (10.0101).
- Transfer of fuel or nuclear material to dedicated buffer storage (10.0102).

Activity Group 10.0200 "Dedicated buffer storage for fuel and/or nuclear material" comprises:

- Construction of buffer storage (10.0201).
- Operation of buffer storage (10.0202).
- Transfer of fuel and/or nuclear material away from the buffer storage (10.0203) includes construction costs (where applicable), operation and maintenance of the buffer storage on site in the case of the ownership of the storage; includes the fees for storage where such storage is provided as a service to the decommissioning project.

Activity Group 10.0300 "Decommissioning of buffer storage" comprises:

- Decommissioning of buffer storage (10.0301).
- Management of waste (10.0302).

Activity Group 10.0300 relates to situations where the decommissioning of the buffer storage is itself within the scope of the decommissioning project. This may be the case of small nuclear facilities such as small research reactors when the buffer storage is an integral part of the facility.

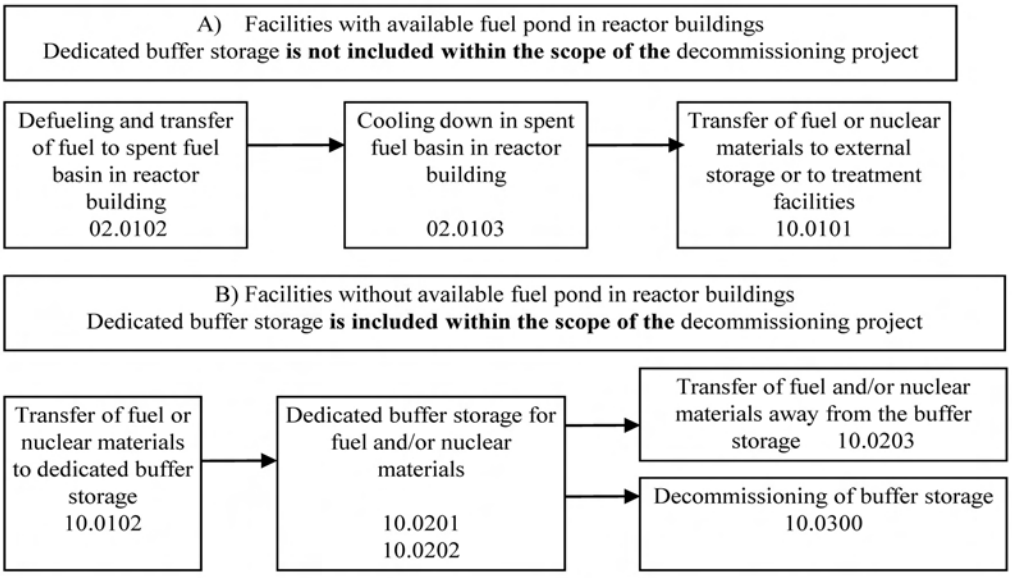
Transfer of the facility to another owner may sometimes be pursued, in which case the transfer cost is included here. Assets in the case of sale of the facility are included within Activity Group 11.0400.

The decommissioning of large storage facilities is generally organised as a separate decommissioning project, using specially-defined Principal Activities 01 to 11. In such cases, Principal Activity 10 applies to the transport of spent fuel to another storage facility.

Determination of costs and financing for Principal Activity 10

The activities may be paid from the decommissioning fund, owner's funds or from the state budget. This situation is country dependent and should be defined in the assumptions and boundary conditions, the most common situation for NPPs being that spent fuel is transported from the cooling system in the reactor building to an external storage facility located away from the facility, where this is available.

Cases for implementation of the external spent fuel storage

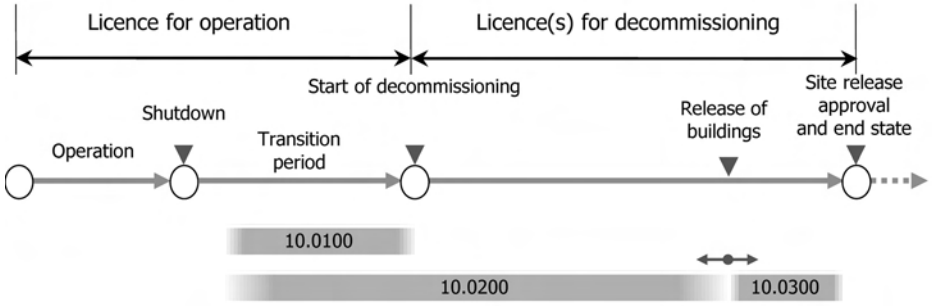


The situation will be different for NPPs, research reactors or other nuclear installations where an external storage facility is not available due to the type of the spent fuel, due to damage of the spent fuel or due to other reasons. Where buffer storage for spent fuel is provided on site, in such cases the costs should be included within the decommissioning cost estimate (construction, licensing, operation, decommissioning), as well as the cost for transfer of the spent fuel from this external storage to its final destination. As an example, special programmes have been implemented for repatriation of high enriched fuel for research reactors.

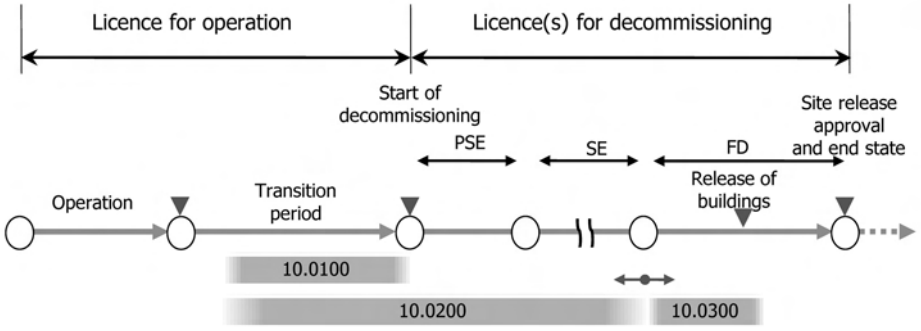
In the case of NPPs with an interim spent fuel store away from the site, only 10.0101 is relevant. For research reactors and facilities where the storage of the spent fuel on site is within the scope of the decommissioning project, all relevant items should be considered. The possible use of external spent fuel storage is illustrated in the figure above.

The extent of activities related to spent fuel should be defined in assumptions and boundary conditions for the decommissioning project.

Typical schedule for decommissioning activities of Principal Activity 10 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 10 for deferred dismantling



Legend: FD: final dismantling; PSE: preparation of safe enclosure; SE: safe enclosure.

3.3.11 Principal Activity 11: Miscellaneous expenditures

11.0100 Owner costs.

- 11.0101 Implementation of transition plans.
- 11.0102 External project to be performed as a consequence of decommissioning.
- 11.0103 Payments (fees) to authorities.
- 11.0104 Specific external services and payments.

11.0200 Taxes.

- 11.0201 Value added taxes.
- 11.0202 Local, community, federal taxes.
- 11.0203 Environmental taxes.
- 11.0204 Taxes on industrial activities.
- 11.0205 Other taxes.

11.0300 Insurances.

- 11.0301 Nuclear related insurances.
- 11.0302 Other insurances.

11.0400 Asset recovery.

11.0401 Asset recovery related to redundant equipment.
11.0402 Asset recovery related to released materials.
11.0403 Asset recovery related to material and equipment from conventional dismantling and demolition.
11.0404 Asset recovery related to buildings and site.
11.0405 Other asset recovery.

General features of Principal Activity 11

Principal Activity 11 involves mainly fixed cost items, rather than decommissioning activities. The cost items of Principal Activity 11 in general are such costs that cannot be allocated directly to items of Principal Activities 01 to 10. All assets during the decommissioning project were centralised in this Principal Activity 11.

Description of Activity Groups (Level 2) and Typical Activities (Level 3)

Activity Group 11.0100 "Owner costs" comprises:

- Implementation of transition plans (11.0101) such as pension schemes or projects related to transition period.
- External project to be performed as a consequence of decommissioning (11.0102), are mostly the project for compensating the consequences of shutdown at the site level and also at other levels (such as municipal level); or other specific project agreed by the stakeholders.
- Payments (fees) to authorities (11.0103).
- Specific external services and payments (11.0104) are items related to involvement of authorities and to specific services and payments which have no direct relation to Principal Activities 01 to 10.

Activity Group 11.0200 "Taxes" comprises:

- Value added taxes (11.0201), if this is the case.
- Local, community, federal taxes (11.0202).
- Environmental taxes (11.0203).
- Taxes on industrial activities (11.0204).
- Other taxes (11.0205).

Activity Group 11.0300 "Insurances" comprises:

- Nuclear related insurances (11.0301).
- Other insurances (11.0302).

Activity Group 11.0400 "Asset recovery" is concerned with all assets during the entire decommissioning project:

- Asset recovery related to redundant equipment (11.0401), sold during the transition period.
- Asset recovery related to released materials (11.0402).
- Asset recovery related to material and equipment from conventional dismantling and demolition (11.0403).
- Asset recovery related to buildings and site (11.0404).
- Other asset recovery (11.0405).

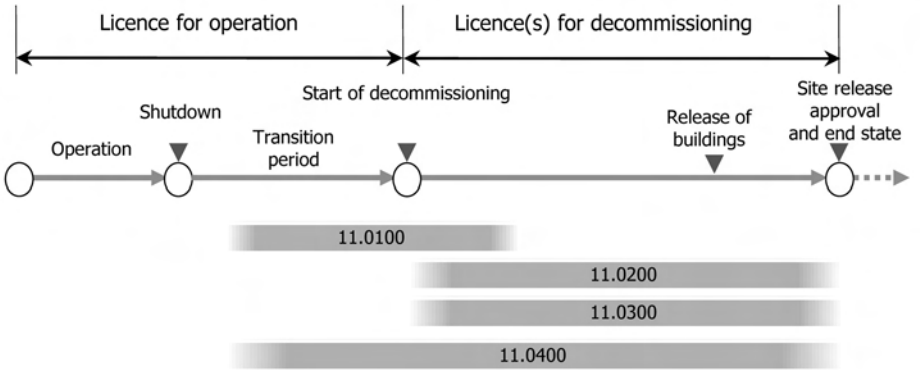
Determination of costs and financing for Principal Activity 11

Principal Activity 11 involves cost items which are directly related to a decommissioning project (i.e. are within the defined scope of the project) but cannot be allocated to Principal Activities 01 to 10. Examples of these items are the transition plans which compensate the shutdown of the facility or the consequences of decommissioning, pension schemes or requalification projects for personnel who leave the nuclear facility to be decommissioned, payments to authorities and various specific external services or payments with no direct allocation to Principal Activities 01 to 10, and taxes and insurances.

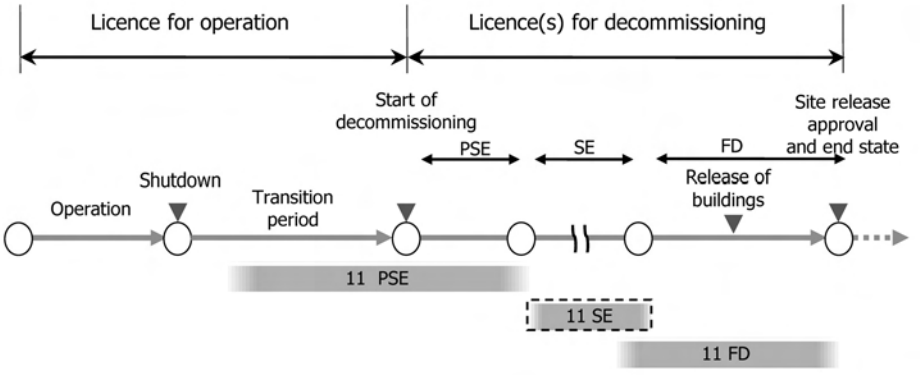
Assets may result from the sale of re-usable equipment or materials as the result of the activities in the Principal Activity 02, Principal Activity 04 or Principal Activity 07. Reuse of the site may play an important role in some cases.

Cost items allocated to Principal Activity 11 are mostly fixed cost items. For many projects the timing of these costs will be an important consideration.

Typical schedule for decommissioning activities of Principal Activity 11 for immediate dismantling



Typical schedule for decommissioning activities of Principal Activity 11 for deferred dismantling



Legend: FD: final dismantling; PSE: preparation of safe enclosure; SE: safe enclosure.

Note: The dashed item "11 SE" indicate that other costs may be implemented also during the safe enclosure period.

3.4 Cost categories

Activity costs are sub-divided according to four main cost categories:

- Labour costs (LBC) – this includes all payments to employees according to national legislation and trade union's agreements; payments to social security and health insurance according to national legislation; all payments to employees agreed in the company and overheads. Care should be taken in definition of the overheads not to duplicate the cost related to personnel involved in the costing structure.

  Labour cost comprises:
  - Salaries.
  - Contributions to social security and health insurance.
  - Company contributions to pension scheme and fringe benefits.
  - Overheads.

- Investment costs (capital, equipment and material costs) (INV) – this includes capital, equipment and material costs. What is included as investment cost is normally defined in the national accounting rules as the limit for procurement of equipment, materials and spare parts.

  Investment cost comprises:
  - Equipment to be used for a particular activity.
  - Machinery to be used for a particular activity.

- Expenses (EXP) – this includes all payments related to decommissioning activities, not identified as labour cost and investment cost.

  Expenses comprise:
  - Consumables.
  - Spare parts.
  - Protective clothing.
  - Travel expenses.
  - Legal expenses.
  - Taxes.
  - Value added tax.
  - Insurance.
  - Consultants.
  - Quality assurance.
  - Rents.
  - Office material.
  - Heating costs.
  - Water costs.
  - Electricity.
  - Computer.
  - Telephone/fax.
  - Cleaning.
  - Interest.
  - Public relations.
  - Licences/patents.
  - Decommissioning authorisation.
  - Income from asset recovery ("negative expenses").

- Contingency (CON) – this represents a specific provision for costs that are not anticipated specifically but which may reasonably be expected to occur in the context of the defined project scope. Contingency allowances will normally differ

for each Principal Activity and will be refined during the sequential upgrading of the cost estimate, as it develops from being a preliminary through to a detailed cost estimate – see Appendix C for a fuller discussion of this topic.

3.5 Presentation matrix for decommissioning costs (ISDC matrix)

The hierarchical cost structure may be represented in a matrix form, with each row representing a separate activity and with the breakdown of costs into different categories being represented by the columns of the matrix. The principal structure of the ISDC matrix is presented in the table below. This matrix also provides a standardised structure for presentation of decommissioning costs.

Structure of the ISDC matrix

Level 1	Level 2	Level 3	Activity	Labour costs	Investment costs	Expenses	Contingency	Total cost	User-defined data extensions			
01			Pre-decommissioning actions									
	01.0100		Decommissioning planning									
		01.0101	Strategic planning									
		01.0102	Preliminary planning									
		01.0103	Final planning									
	01.0200		Facility characterisation									
		01.0201	Detailed facility characterisation									
		01.0202	Hazardous-material surveys and analyses									
		01.0203	Establishing a facility inventory database									
	Etc.											
02			Facility shutdown activities									
03												
04												
05												
06												
07												
08												
09												
10												
11												
Total												

Aggregating the data at the first level

Aggregating the data at the second level

Entering data at the third level

Total data of the project

4. Application of the ISDC

4.1 Relationship of the ISDC to the decommissioning process and costing

4.1.1 Approaches to cost calculation

Decommissioning involves a set of discrete activities for which specific resources may be identified, such as the quantity of materials to be handled (e.g. dismantled), the number of personnel involved in the activity, the duration of the activity, conditions for performing the activity and other parameters. Similar elementary activities may be repeated many times within a decommissioning project with appropriate resources. The ISDC aims to provide a systematic structure for identifying the costs of these typical decommissioning activities.

The process for decommissioning cost estimation, according to many costing methodologies [3, 11, 12, 13] is related to individual elementary decommissioning activities, i.e. costs and other decommissioning parameters are evaluated for individual elementary decommissioning activities, for groups of decommissioning activities and for entire decommissioning projects.

The elementary activities of a decommissioning project may be organised according to various structures – see Section 4.2. One approach is to determine costs for the elementary decommissioning activities according to the ISDC structure from the outset, with additional hierarchical levels being introduced by the cost estimator where required. Such additional levels may be used: to differentiate various phases of the decommissioning project as well as to reflect the hierarchical structure of the facility inventory database (such as buildings, floors, rooms, and equipment), technical systems, elements of organisational structure, etc. Following this approach, the resulting costs are then structured directly according to the ISDC.

An alternative approach is to calculate costs (at least in the first instance) according to the activities defined in the WBS for the decommissioning project. The WBS organises the decommissioning activities according to the sequence of work packages defined for planning and managing the decommissioning project. Costs may be determined for elementary decommissioning activities and the resulting cost estimate follows the WBS for the decommissioning project. Costs calculated according to this approach can then be converted to the ISDC, provided a direct correspondence with activities at Level 3 can be established.

4.1.2 Cost categories

In costing methodologies based on the ISDC structure, the costs for individual decommissioning activities are normally calculated according to the cost categories as defined in the ISDC, i.e. labour cost, investment, expenses and contingency. For some elementary decommissioning activities which are considered as services from the point of view of the decommissioning project, only one figure may be available. In such cases the cost is regarded as an expense, with contingency being estimated separately.

Where costs are determined initially according to a cost structure which is different to the ISDC cost categories, a correspondence with the latter will need to be established in order that costs can be presented according to the ISDC. Groups of decommissioning

activities may be identified which have a typical distribution of costs according to the ISDC. These typical distributions may be represented as reference cost categories, e.g. for waste management activities, dismantling activities, management/support activities. These distributions may also be useful in assisting the transformation of non-ISDC cost categories into the ISDC cost structure.

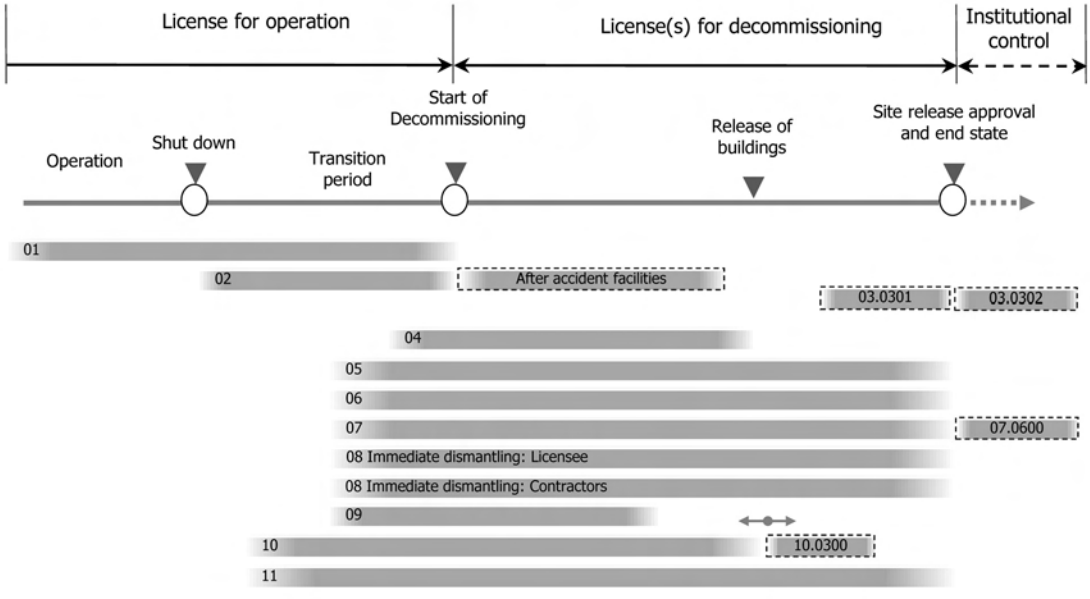
4.1.3 Allocation of costs to phases of decommissioning projects

Decommissioning projects, depending on the chosen strategy (immediate dismantling, deferred dismantling and entombment) may have several main phases. Typical decommissioning activities, as they are systematised in the ISDC structure, may be repeated in several phases of a decommissioning project. A typical distribution of activities for Principal Activities 01 to 11 for the immediate dismantling option and for the deferred decommissioning option with safe enclosure are presented in the figures below. The entombment decommissioning option involves essentially the same front-end decommissioning activities as for the immediate or deferred option, though with a different end state. Activities for achieving this state are addressed by Activity 03.0302.

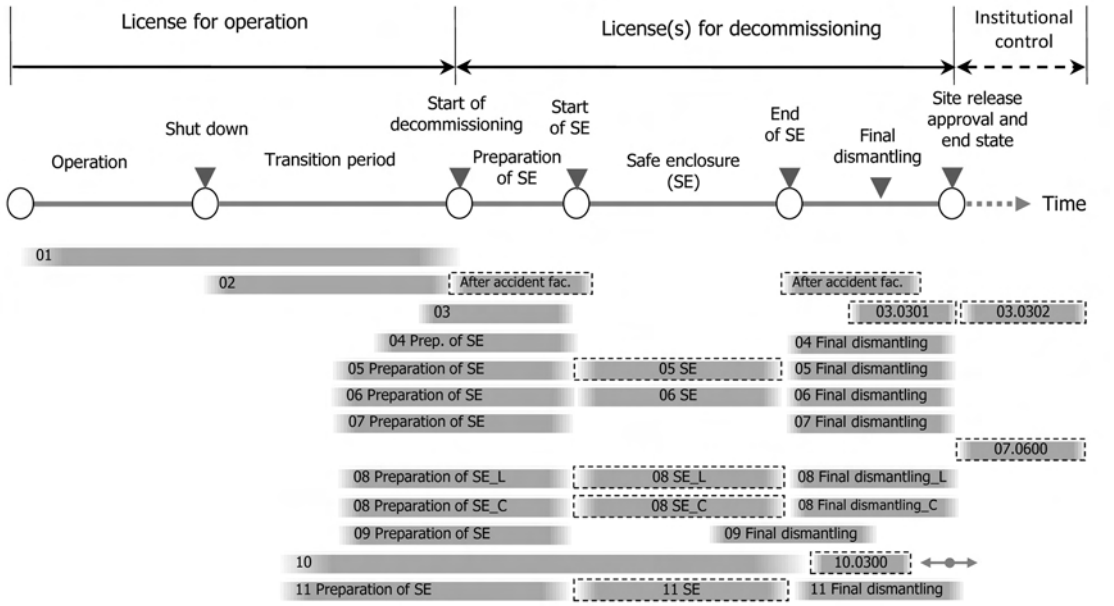
Different phases of a decommissioning project, each involving the same decommissioning activities at the third hierarchical level, may be distinguished by additional numbering below the third level, reflecting the particular project phase. This allows all costs associated with a specific phase to be identified separately, and may also be useful in establishing correspondence between WBS and ISDC items (see Section 4.2).

Different strategies may be applied to the licensing of individual phases of decommissioning, from one an approach based on a single licence for the entire project to staged licensing linked to the main decommissioning phases. In the latter case certain activities related to licensing may be repeated several times, and the allocations to ISDC Principal Activities may be different. In such cases, the licensing of the first decommissioning phase is allocated to Principal Activity 01, licensing of other phases is allocated to Principal Activity 08.

Typical distribution of Principal Activities 01 to 11 for immediate dismantling decommissioning option



Typical distribution of Principal Activities 01 to 11
for deferred dismantling decommissioning option with safe enclosure



Legend: C: contractor; L: licensee; SE: safe enclosure.

Note: The activities identified by dashed lines occur only in specific cases.

Decommissioning planning activities are included into individual decommissioning costing cases to the extent allowed by relevant national legislation, which defines those activities that can be funded from a national decommissioning fund. The cost of all activities that comprise the decommissioning project needs to be evaluated, regardless of whether the activities will be performed by personnel of the owner or the activities will be contracted.

4.1.4 Implications of sources of funding for decommissioning costing

The first aspect refers to funds which are used for financing of individual decommissioning activities. According to the definition, the ISDC involves all typical decommissioning activities which can be identified in any decommissioning project. There are several possibilities for financing individual decommissioning activities such as:

- decommissioning fund collected during the operation of the nuclear facility; this is the primary standard source for financing of NPPs and other large facilities;
- owner's fund collected to cover selected activities, e.g. costs for the transition period; specific funds can be collected according to the national accounting legislation;
- state budget; examples may be state-owned research facilities; and
- other funds; e.g. international funds for partial coverage of the decommissioning costs for NPPs shutdown by international agreements.

In general, the decommissioning activities that can be paid from the decommissioning fund are determined in accordance with national legislation. Significant differences between national approaches may occur especially in the case of Principal Activity 02 (i.e. the extent of decommissioning activities which can be paid from a national decommissioning fund), and to a lesser extent for Principal Activities 01, 07, 10 and 11. There may be phases in a decommissioning process where funding is partially provided

from a national decommissioning fund and partially provided from owner's funds, e.g. sub-activities of Principal Activity 02. In the case of the latter, costs may still be determined according to the ISDC, though these costs will not be included in the decommissioning cost estimate. All aspects of funding should be clearly defined in assumptions and boundary conditions for a decommissioning project.

4.1.5 *Legacy issues, post-accidental situations*

Decommissioning plans are generally prepared on the basis of standard assumptions and boundary conditions relating to the start of decommissioning, including:

- No operational waste at the facility.
- No spent fuel at the facility.
- Primary systems empty, dry, decontaminated.
- No leakages have occurred during operation.
- No accidents have occurred during operation.
- Waste management system is available.

In cases where at least one of the above listed items is not fulfilled, some modifications will be needed to the standard composition of ISDC activities. These may include:

- Extending the characterisation activities of Principal Activities 01, 02, 04.
- More extensive studies necessary in support of the planning and safety evaluation activities within Principal Activity 01.
- Extending Principal Activity 02 by inclusion of special activities and by prolonging the duration of the transition period and also prolonging some activities during the decommissioning period.
- Extending decontamination and dismantling activities of Principal Activity 04 due to more complex radiological conditions in systems and structures, implementation of specific or adapted techniques, placing greater reliance on remote controlled techniques, removal of contaminated soil etc.
- Additional requirements on the waste management system.
- Processing of historical and legacy waste.
- Different composition of decommissioning waste due to non-standard radiological conditions in systems and structures;
- Extending Principal Activity 06 to ensure the safety such as surveillance, maintenance, radiation protection, operation of support systems, etc.
- Extending activities for site remediation.
- Extending management activities and support.
- Additional requirements on research and development to understand better the baseline situation at the facility, to develop or adapt solutions and to ensure safety in systems, structures and decommissioning processes.
- Additional activities in the case of damaged spent fuel and other spent fuel related aspects.

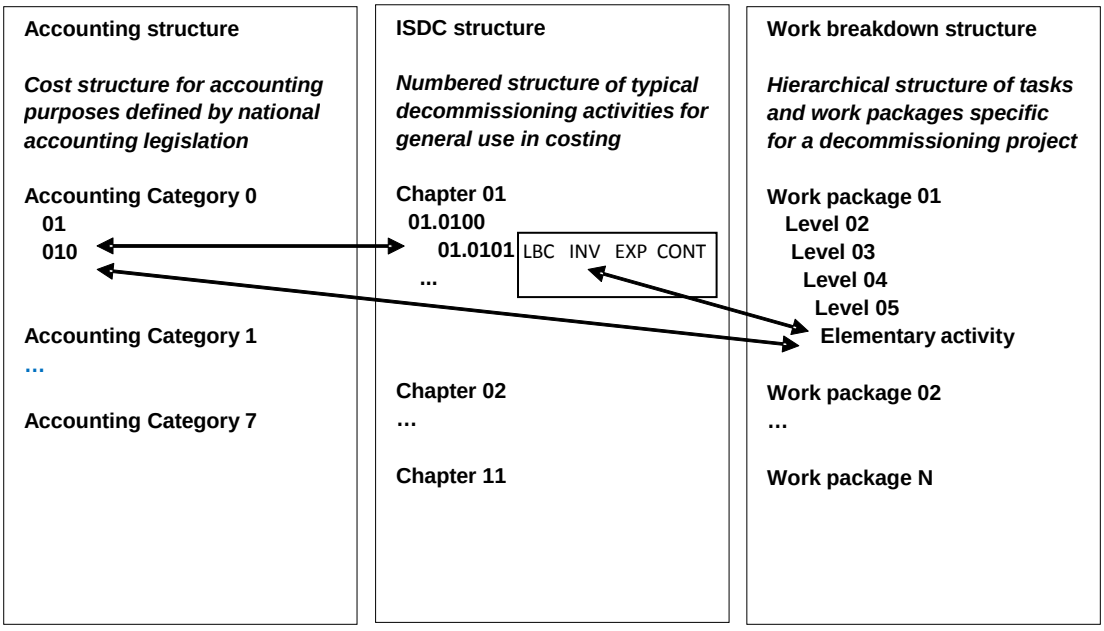
The non-standard assumptions and boundary conditions listed above may also have significant impacts on Principal Activity 11, e.g. on owner costs for additional projects to deal with the consequences of shutdown due to political decisions. In these cases, the

standard ISDC can be effectively used as a checklist or as guidance for ensuring that all relevant decommissioning activities are considered in the project.

4.1.6 *Other structures involved in decommissioning costing with relation to the ISDC structure*

Except for the ISDC structure, the ISDC calculation structure and the WBS of a decommissioning project, there are also other cost structures that should be taken into consideration as subjects of accounting during planning, conduct and documentation of the decommissioning activities. This section presents basic relations between the three main cost structures involved in decommissioning costing as presented in the figure below. It is not the subject of this document to presents detailed solutions for linking to the accounting structure, but only to inform about the principles of relations of the ISDC and WBS to the accounting structure.

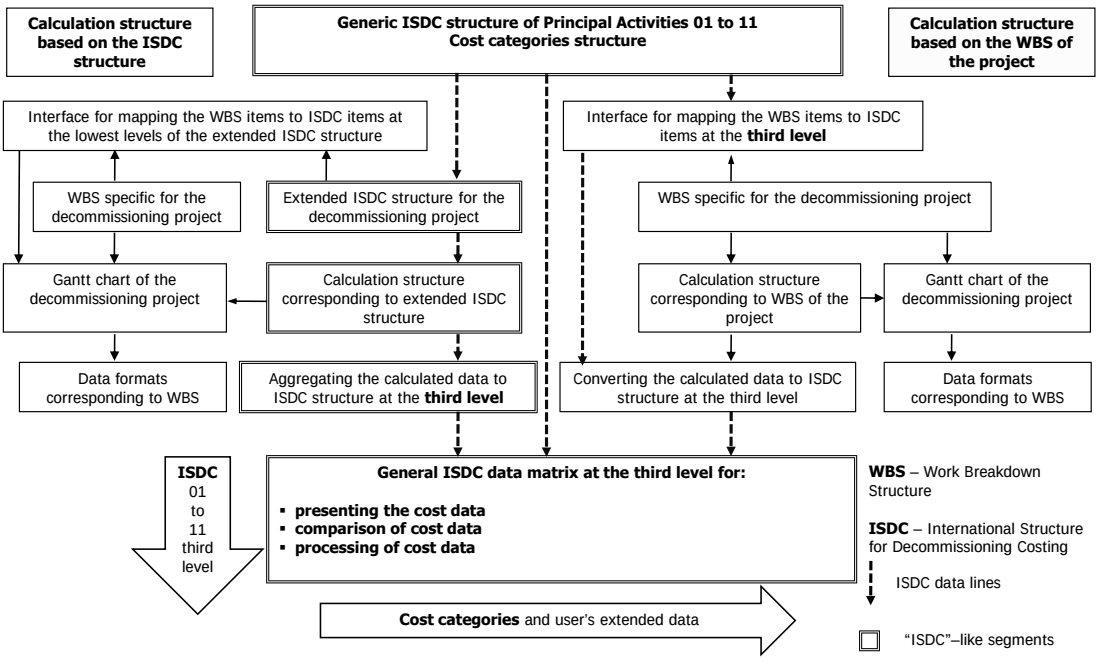
Relationship between the ISDC structure, the WBS and the accounting structure



4.2 Approaches for implementation of the ISDC in costing

As noted in Section 4.1, decommissioning costs may be directly using the ISDC or may alternatively be determined initially using the WBS for the project, in which case they should then be mapped onto the ISDC. The principles of both approaches are presented in the figure below. In the former case (shown on the left of the figure), the ISDC, extended as necessary to lower hierarchical level provides the basic structure for calculation of costs, with an interface being created to the project WBS, in order that cost data can be associated with the planning schedule for the project. In the latter case (shown on the right of the figure), the WBS provides the basic structure for calculation of costs, and an interface is developed between the WBS activities and the ISDC (Level 3 activities) to facilitate the presentation of costs according to the ISDC. The figure shows the main relationships between the generic ISDC structure, cost calculation structures, WBS of decommissioning projects and Gantt chart as the representation of the WBS in planning and management systems.

Principles of two basic approaches for implementing the ISDC in decommissioning costing



4.2.1 Use of the ISDC structure for mapping WBS items to ISDC items

This approach requires that the items at the lowest levels of the WBS items link to ISDC items at the third level. The principle of this mapping is presented in the figure below. The core of the mapping is an interface (table) that links the WBS items to ISDC items.

Principles of linking the WBS items to ISDC items at third level

WBS of the decommissioning project			Interface WBS-ISDC		ISDC structure		
Level	WBS ID	Name	WBS ID	ISDC-3rd level	Level 1	Level 2	Level 3
1		Decommissioning of …			01		
2	1	Documentation for …				01.0100	
3	1.1						01.0101
4	1.1.1						01.0102
5	1.1.1.1						01.0103
6	1.1.1.1.1	Decommissioning plan for …	1.1.1.1.1	01.0103		01.0200	
6	1.1.1.1.2	Supporting document A	1.1.1.1.2	01.0103			
6	1.1.1.1.3	Supporting document B	1.1.1.1.3	01.0103			
	etc.						
2	7	Dismantling of reactor …			04		
3	7.1					04.0100	
4	7.1.1					04.0200	
5	7.1.1.1.						
6	7.1.1.1.1					04.0500	
7	7.1.1.1.1.1	Dismantling of component A	7.1.1.1.1.1	04.0501			04.0501
7	7.1.1.1.1.2	Dismantling of component B	7.1.1.1.1.2	04.0501			04.0502
7	7.1.1.1.1.3	Dismantling of component C	7.1.1.1.1.3	04.0501			
	etc.						

4.2.2 Use of the ISDC as the cost calculation structure

Although cost estimates can be developed directly using the ISDC cost structure, or may be developed according to another structure and then mapped onto the ISDC structure, the former approach may be less labour intensive, especially where a new costing methodology is being developed. The benefits of using the ISDC as the cost calculation structure from the outset are summarised in the box below.

The calculation core of any code can be the same as for the structure of decommissioning activities at least to the first three standardised classification levels.

The bottom-up principle is easy to implement. The cost is calculated at the lowest level and can be grouped and accumulated upwards.

Costs and other decommissioning parameters may be presented according to a uniform structure starting from the third level upwards.

The extent of the calculation related to the scope of the decommissioning project is easy to define in the calculation structure. The broad calculation structure can be the same for all cases but the extent of calculation can be adjusted for individual calculated cases by including or excluding decommissioning activities in/from the costing procedure.

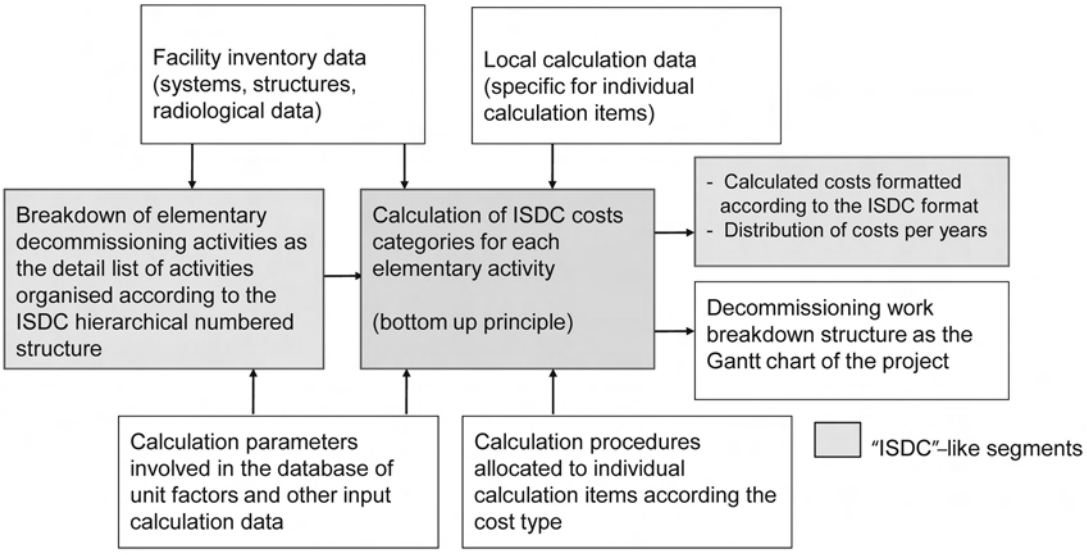
The identification of cost items by the three numbered ISDC levels is unambiguous. The cost structures of different decommissioning projects are then comparable and more transparent.

The management of cost items at levels lower than the third level can be specific for individual codes, but the uniformity at the third level and upwards remains.

Numbering of discretionary levels lower than the third numbered level is easy to implement.

The approach to cost calculation using the ISDC as the basis of the cost calculation methodology is summarised in the figure below.

Scheme of the cost calculation methodology for the ISDC costing model



4.3 Cost estimate reporting

4.3.1 Reporting formats

The planning and optimisation of the decommissioning process generally requires that two cost reporting formats be used:

- total costs estimation formats; and
- cost time distribution formats.

Total cost estimation formats

The recommended format for presenting total decommissioning costs (see table below) is generally based on the ISDC matrix (see Section 3.5):

- The horizontal axis represents the cost categories, i.e. labour costs (L), investments (I), expenses (E), contingency (C) and total costs (T). Cost items higher levels of the ISDC structure represent the summation of all relevant cost items at the lower levels of the structure (e.g. $L_{01} = L_{01.0100} + L_{01.0200} + L_{01.0300} + ...$).
- The vertical axis represents the decommissioning activities reflecting the ISDC structure. The level of detail (first, second or third level) in the reported activities may vary depending on the purposes of further application of the output data in the decommissioning planning process.

Example of basic cost estimation data matrix

Decommissioning activity	Cost categories				
	Labour costs	Investments	Expenses	Contingency	Total
01 Pre-decommissioning actions	L_{01}	I_{01}	E_{01}	C_{01}	$L_{01}+I_{01}+E_{01}+C_{01}$
01.0100 Decommissioning planning	$L_{01.0100}$	$I_{01.0100}$	$E_{01.0100}$	$C_{01.0100}$	$L_{01.0100}+I_{01.0100}+E_{01.0100}+C_{01.0100}$
01.0101 Strategic planning	$L_{01.0101}$	$I_{01.0101}$	$E_{01.0101}$	$C_{01.0101}$	$L_{01.0101}+I_{01.0101}+E_{01.0101}+C_{01.0101}$
...					
...					
...					
01.0200 Facility characterisation	$L_{01.0200}$	$I_{01.0200}$	$E_{01.0200}$	$C_{01.0200}$	$L_{01.0200}+I_{01.0200}+E_{01.0200}+C_{01.0200}$
...					
...					
...					
02 Facility shutdown activities	L_{02}	I_{02}	E_{02}	C_{02}	$L_{02}+I_{02}+E_{02}+C_{02}$
...					
...					
...					
Total costs	L_{01-11}	I_{01-11}	E_{01-11}	C_{01-11}	$L_{01-11}+I_{01-11}+E_{01-11}+C_{01-11}$

The need to present total cost data according to different reporting formats may occur during the decommissioning planning process, e.g. where the decommissioning strategy involves the use of external companies in such a way that each building (group of buildings) represents an independent decommissioning project. The contracted company carries out selected decommissioning activities on selected buildings according to the requirements of the decommissioning licensee. In this situation costs are reported separately for each contracted building, reflecting the scope of the decommissioning activities (usually dismantling and demolition) being done by the contractor(s).

Separation of costs according to different parts of the facility is achieved by use of a fourth hierarchical level, which is defined by the cost estimator – see table below. This table presents an example of dismantling activities outside the controlled area (Principal Activity 07) separately for three civil buildings (CB) – CB1, CB2, and CB3. Based on the reported results for cost data items, it is possible for the licensee to calculate the values of the three contracts separately.

Example of cost estimation data matrix part organised according to building structure

Decommissioning activity	Cost categories				
	Labour costs	Investments	Expenses	Contingency	Total
01 Pre-decommissioning actions					
07 Conventional dismantling, demolition and site restoration - CB1	L_{07}	I_{07}	E_{07}	C_{07}	$L_{07}+I_{07}+E_{07}+C_{07}$
07.0100 Procurement of equipment for conventional dismantling…. - CB1	$L_{07.0100}$	$I_{07.0100}$	$E_{07.0100}$	$C_{07.0100}$	$L_{07.0100}+I_{07.0100}+E_{07.0100}+C_{07.0100}$
07.0200 Dismantling of systems and building components….- CB1	$L_{07.0200}$	$I_{07.0200}$	$E_{07.0200}$	$C_{07.0200}$	$L_{07.0200}+I_{07.0200}+E_{07.0200}+C_{07.0200}$
07.0201 Electricity generating system - CB1	$L_{07.0201}$	$I_{07.0201}$	$E_{07.0201}$	$C_{07.0201}$	$L_{07.0201}+I_{07.0201}+E_{07.0201}+C_{07.0201}$
07.0202 Cooling system components - CB1	$L_{07.0202}$	$I_{07.0202}$	$E_{07.0202}$	$C_{07.0202}$	$L_{07.0202}+I_{07.0202}+E_{07.0202}+C_{07.0202}$
07 Conventional dismantling, demolition and site restoration - CB2	L_{07}	I_{07}	E_{07}	C_{07}	$L_{07}+I_{07}+E_{07}+C_{07}$
07.0100 Procurement of equipment for conventional dismantling…. - CB2	$L_{07.0100}$	$I_{07.0100}$	$E_{07.0100}$	$C_{07.0100}$	$L_{07.0100}+I_{07.0100}+E_{07.0100}+C_{07.0100}$
07.0200 Dismantling of systems and building components….- CB2	$L_{07.0200}$	$I_{07.0200}$	$E_{07.0200}$	$C_{07.0200}$	$L_{07.0200}+I_{07.0200}+E_{07.0200}+C_{07.0200}$
07.0201 Electricity generating system - CB2	$L_{07.0201}$	$I_{07.0201}$	$E_{07.0201}$	$C_{07.0201}$	$L_{07.0201}+I_{07.0201}+E_{07.0201}+C_{07.0201}$
07.0202 Cooling system components - CB2	$L_{07.0202}$	$I_{07.0202}$	$E_{07.0202}$	$C_{07.0202}$	$L_{07.0202}+I_{07.0202}+E_{07.0202}+C_{07.0202}$
07 Conventional dismantling, demolition and site restoration - CB3	L_{07}	I_{07}	E_{07}	C_{07}	$L_{07}+I_{07}+E_{07}+C_{07}$
07.0100 Procurement of equipment for conventional dismantling…. - CB3	$L_{07.0100}$	$I_{07.0100}$	$E_{07.0100}$	$C_{07.0100}$	$L_{07.0100}+I_{07.0100}+E_{07.0100}+C_{07.0100}$
07.0200 Dismantling of systems and building components….- CB3	$L_{07.0200}$	$I_{07.0200}$	$E_{07.0200}$	$C_{07.0200}$	$L_{07.0200}+I_{07.0200}+E_{07.0200}+C_{07.0200}$
07.0201 Electricity generating system - CB3	$L_{07.0201}$	$I_{07.0201}$	$E_{07.0201}$	$C_{07.0201}$	$L_{07.0201}+I_{07.0201}+E_{07.0201}+C_{07.0201}$
07.0202 Cooling system components - CB3	$L_{07.0202}$	$I_{07.0202}$	$E_{07.0202}$	$C_{07.0202}$	$L_{07.0202}+I_{07.0202}+E_{07.0202}+C_{07.0202}$

Cost time distribution formats

The time distribution of each significant cost item may need to be reported in a suitable format to facilitate budget planning for each phase of decommissioning. This enables more detailed planning according to the defined phases of the project, including:

- Determining a range of investments in new technologies, facilities or equipment that are necessary to complete the planned decommissioning process.
- Estimation of expenses for providing all planned decommissioning activities.
- Definition of personnel requirements for each relevant ISDC structure item during the time resulting in the inevitable labour costs for planned activities.
- Allocation of appropriate contingency amounts in the decommissioning budget for each relevant activity and time period during the process.

For planning of large decommissioning projects, cost data may need to be reported for periods of one year, e.g. to coincide with funding requirements. In certain cases, especially for small decommissioning projects, more detailed (quarterly or monthly) cost flow formats may be needed.

The distribution of cost data in time could be presented in various formats such as:

- Graphs (histograms) showing selected cost data items on the y-axis and time on the x-axis.
- Gantt chart as a standard format for reporting the schedule of the project. Adding a data source for each activity to the Gantt chart structure makes it possible to report the time distribution of cost parameters.
- Multi-dimensional table is understood as an extension of a matrix for reporting the total cost (cf. table above). The next dimension of the table is represented by the requested time periods for reporting the individual cost data items (table below).

Cost time distribution in a multi-dimensional table

Decommissioning activity	Time period A					Time period B					...	Time period N				
	Cost categories															
	L_A	I_A	E_A	C_A	T_A	L_B	I_B	E_B	C_B	T_B		L_N	I_N	E_N	C_N	T_N
01 Pre-decommissioning actions	L_{A-01}	I_{A-01}	E_{A-01}	C_{A-01}	T_{A-01}	L_{B-01}	I_{B-01}	E_{B-01}	C_{B-01}	T_{B-01}	...	L_{N-01}	I_{N-01}	E_{N-01}	C_{N-01}	T_{N-01}
01.0100 Decommissioning planning	$L_{A-01.0100}$	$I_{A-01.0100}$	$E_{A-01.0100}$	$C_{A-01.0100}$	$T_{A-01.0100}$	$L_{B-01.0100}$	$I_{B-01.0100}$	$E_{B-01.0100}$	$C_{B-01.0100}$	$T_{B-01.0100}$	...	$L_{N-01.0100}$	$I_{N-01.0100}$	$E_{N-01.0100}$	$C_{N-01.0100}$	$T_{N-01.0100}$
01.0101 Strategic planning	$L_{A-01.0101}$	$I_{A-01.0101}$	$E_{A-01.0101}$	$C_{A-01.0101}$	$T_{A-01.0101}$	$L_{B-01.0101}$	$I_{B-01.0101}$	$E_{B-01.0101}$	$C_{B-01.0101}$	$T_{B-01.0101}$	...	$L_{N-01.0101}$	$I_{N-01.0101}$	$E_{N-01.0101}$	$C_{N-01.0101}$	$T_{N-01.0101}$
...											...					
...											...					
...											...					
01.0200 Facility characterisation	$L_{A-01.0200}$	$I_{A-01.0200}$	$E_{A-01.0200}$	$C_{A-01.0200}$	$T_{A-01.0200}$	$L_{B-01.0200}$	$I_{B-01.0200}$	$E_{B-01.0200}$	$C_{B-01.0200}$	$T_{B-01.0200}$	...	$L_{N-01.0200}$	$I_{N-01.0200}$	$E_{N-01.0200}$	$C_{N-01.0200}$	$T_{N-01.0200}$
...											...					
...											...					
...											...					
02 Facility shutdown activities	L_{A-02}	I_{A-02}	E_{A-02}	C_{A-02}	T_{A-02}	L_{B-02}	I_{B-02}	E_{B-02}	C_{B-02}	T_{B-02}	...	L_{N-02}	I_{N-02}	E_{N-02}	C_{N-02}	T_{N-02}
...											...					
...											...					
...											...					
Total costs for time period	$L_{A-01-11}$	$I_{A-01-11}$	$E_{A-01-11}$	$C_{A-01-11}$	$T_{A-01-11}$	$L_{B-01-11}$	$I_{B-01-11}$	$E_{B-01-11}$	$C_{B-01-11}$	$T_{B-01-11}$	...	$L_{N-01-11}$	$I_{N-01-11}$	$E_{N-01-11}$	$C_{N-01-11}$	$T_{N-01-11}$

4.3.2 Cost reporting presentation

To present the cost of decommissioning in the ISDC structure (e.g. in a conceptual decommissioning plan) it is recommended to use the following content:

- Executive summary highlighting the main points of the cost estimation report.
- Facility description which characterises the main systems of the nuclear facility and discusses in detail the facility material and radiological inventory which significantly influences the cost parameters.
- Selected decommissioning strategy and approach, describing and analysing the technologies to be used, including the methods and principles (for dismantling, decontamination, radioactive waste management scenario etc.) for achieving the planned final state of the site after completion of decommissioning, highlighting the impact on cost estimation or decommissioning funding.
- Methodology for cost estimation providing a detailed description of the methodology applied for cost estimation, including cost calculation methods used (calculation code).
- Assumptions and boundary conditions defining the input parameters, constraints and restrictions limiting the process of decommissioning and cost estimation.
- Results and tables are considered to be the most important part of the report, presenting in various formats the results of the cost calculation, usually for more than one decommissioning option, the analysis of the results, and selection of the optimal decommissioning option.
- Conclusions summarising the main points of the report and emphasising the most important results in respect of decommissioning costs.

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Appendix A: Summary of cost item hierarchy

01 Pre-decommissioning actions

01.0100 Decommissioning planning.

01.0101 Strategic planning.
01.0102 Preliminary planning.
01.0103 Final planning.

01.0200 Facility characterisation.

01.0201 Detailed facility characterisation.
01.0202 Hazardous-material surveys and analyses.
01.0203 Establishing a facility inventory database.

01.0300 Safety, security and environmental studies.

01.0301 Decommissioning safety analysis.
01.0302 Environmental impact assessment.
01.0303 Safety, security and emergency planning for site operations.

01.0400 Waste management planning.

01.0401 Establish waste management criteria.
01.0402 Develop a waste management plan.

01.0500 Authorisation.

01.0501 License applications and license approvals.
01.0502 Stakeholder involvement.

01.0600 Preparing management group and contracting.

01.0601 Management team activities.
01.0602 Contracting activities.

02 Facility shutdown activities

02.0100 Plant shutdown and inspection.

02.0101 Termination of operation, plant stabilisation, isolation and inspection.
02.0102 Defueling and transfer of fuel to spent-fuel storage.
02.0103 Cooling down of spent fuel.
02.0104 Management of fuel, fissile and other nuclear materials.
02.0105 Isolation of power equipment.
02.0106 Facility reuse.

02.0200 Drainage and drying of systems.

02.0201 Drainage and drying of closed systems not in operation.
02.0202 Drainage of spent-fuel pool and other open systems not in operation.
02.0203 Removal of sludge and products from open systems.
02.0204 Drainage of special process fluids.

02.0300 Decontamination of closed systems for dose reduction.

02.0301 Decontamination of process installations using operational procedures.
02.0302 Decontamination of process installations using additional procedures.

02.0400 Radiological inventory characterisation to support detailed planning.

- 02.0401 *Radiological inventory characterisation.*
- 02.0402 *Underground water monitoring.*

02.0500 Removal of system fluids, operational waste and redundant material.

- 02.0501 *Removal of combustible material.*
- 02.0502 *Removal of system fluids (water, oils, etc.).*
- 02.0503 *Removal of special system fluids.*
- 02.0504 *Removal of waste from decontamination.*
- 02.0505 *Removal of spent resins.*
- 02.0506 *Removal of specific operational waste from fuel cycle facilities.*
- 02.0507 *Removal of other waste from facility operations.*
- 02.0508 *Removal of redundant equipment and materials.*

03 Additional activities for safe enclosure or entombment

03.0100 Preparation for safe enclosure.

- 03.0101 *Decontamination of selected components and areas to facilitate safe enclosure.*
- 03.0102 *Zoning for long-term storage.*
- 03.0103 *Removal of inventory not suitable for safe enclosure.*
- 03.0104 *Dismantling and transfer of contaminated equipment and material to containment structure for long-term storage.*
- 03.0105 *Radiological inventory characterisation for safe enclosure.*

03.0200 Site boundary reconfiguration, isolating and securing structures.

- 03.0201 *Modification of auxiliary systems.*
- 03.0202 *Site boundary reconfiguration.*
- 03.0203 *Construction of temporary enclosures, stores, structural enhancements, etc.*
- 03.0204 *Stabilisation of radioactive and hazardous waste pending remediation.*
- 03.0205 *Facility controlled area hardening, isolation for safe enclosure.*

03.0300 Facility entombment.

- 03.0301 *Facility entombment as end state of decommissioning strategy.*
- 03.0302 *Institutional control and monitoring of the entombment end state.*

04 Dismantling activities within the controlled area

04.0100 Procurement of equipment for decontamination and dismantling.

- 04.0101 *Procurement of general site-dismantling equipment.*
- 04.0102 *Procurement of equipment for decontamination of personnel and tools.*
- 04.0103 *Procurement of special tools for dismantling the reactor systems.*
- 04.0104 *Procurement of special tools for dismantling in fuel cycle facilities.*
- 04.0105 *Procurement of special tools for dismantling other components or structures.*

04.0200 Preparations and support for dismantling.

- 04.0201 *Reconfiguration of existing services, facilities and site to support dismantling.*
- 04.0202 *Preparation of infrastructure and logistics for dismantling.*
- 04.0203 *Ongoing radiological characterisation during dismantling.*

04.0300 Pre-dismantling decontamination.

- 04.0301 *Drainage of remaining systems.*
- 04.0302 *Removal of sludge and products from remaining systems.*

- 04.0303 *Decontamination of remaining systems.*
- 04.0304 *Decontamination of areas in buildings.*

04.0400 Removal of materials requiring specific procedures.

- 04.0401 *Removal of thermal insulation.*
- 04.0402 *Removal of asbestos.*
- 04.0403 *Removal of other hazardous materials.*

04.0500 Dismantling of main process systems, structures and components.

- 04.0501 *Dismantling of reactor internals.*
- 04.0502 *Dismantling of reactor vessel and core components.*
- 04.0503 *Dismantling of other primary loop components.*
- 04.0504 *Dismantling of main process systems in fuel cycle facilities.*
- 04.0505 *Dismantling of main process systems in other nuclear facilities.*
- 04.0506 *Dismantling of external thermal/biological shields.*

04.0600 Dismantling of other systems and components.

- 04.0601 *Dismantling of auxiliary systems.*
- 04.0602 *Dismantling of remaining components.*

04.0700 Removal of contamination from building structures.

- 04.0701 *Removal of embedded elements in buildings.*
- 04.0702 *Removal of contaminated structures.*
- 04.0703 *Decontamination of buildings.*

04.0800 Removal of contamination from areas outside buildings.

- 04.0801 *Removal of underground contaminated pipes and structures.*
- 04.0802 *Removal of contaminated soil and other contaminated items.*

04.0900 Final radioactivity survey for release of buildings.

- 04.0901 *Final radioactivity survey of buildings.*
- 04.0902 *Declassification of buildings.*

05 Waste processing, storage and disposal

05.0100 Waste management system.

- 05.0101 *Establishing the waste management system.*
- 05.0102 *Reconstruction of existing facilities for decommissioning waste management system.*
- 05.0103 *Procurement of additional equipment for management of historical/legacy waste.*
- 05.0104 *Maintenance, surveillance and operational support for waste management system.*
- 05.0105 *Demobilisation/decommissioning of waste management system.*

05.0200 Management of historical/legacy high-level waste.

- 05.0201 *Characterisation.*
- 05.0202 *Retrieval and processing.*
- 05.0203 *Final conditioning.*
- 05.0204 *Storage.*
- 05.0205 *Transport.*
- 05.0206 *Disposal.*
- 05.0207 *Containers.*

05.0300 Management of historical/legacy intermediate-level waste.

- 05.0301 *Characterisation.*
- 05.0302 *Retrieval and processing.*
- 05.0303 *Final conditioning.*

- 05.0304 *Storage.*
- 05.0305 *Transport.*
- 05.0306 *Disposal.*
- 05.0307 *Containers.*

05.0400 Management of historical/legacy low-level waste.

- 05.0401 *Characterisation.*
- 05.0402 *Retrieval and treatment.*
- 05.0403 *Final conditioning.*
- 05.0404 *Storage.*
- 05.0405 *Transport.*
- 05.0406 *Disposal.*
- 05.0407 *Containers.*

05.0500 Management of historical/legacy very low-level waste.

- 05.0501 *Characterisation.*
- 05.0502 *Retrieval, treatment and packaging.*
- 05.0503 *Transport.*
- 05.0504 *Disposal.*

05.0600 Management of historical/legacy exempt waste and materials.

- 05.0601 *Retrieval, treatment and packaging.*
- 05.0602 *Clearance measurement of exempt waste and materials.*
- 05.0603 *Transport of hazardous waste.*
- 05.0604 *Disposal of hazardous waste at dedicated waste dumps.*
- 05.0605 *Transport of conventional waste and materials.*
- 05.0606 *Disposal of conventional waste at conventional waste dumps.*

05.0700 Management of decommissioning high-level waste.

- 05.0701 *Characterisation.*
- 05.0702 *Processing.*
- 05.0703 *Final conditioning.*
- 05.0704 *Storage.*
- 05.0705 *Transport.*
- 05.0706 *Disposal.*
- 05.0707 *Containers.*

05.0800 Management of decommissioning intermediate-level waste.

- 05.0801 *Characterisation.*
- 05.0802 *Processing.*
- 05.0803 *Final conditioning.*
- 05.0804 *Storage.*
- 05.0805 *Transport.*
- 05.0806 *Disposal.*
- 05.0807 *Containers.*

05.0900 Management of decommissioning low-level waste.

- 05.0901 *Characterisation.*
- 05.0902 *Processing.*
- 05.0903 *Final conditioning.*
- 05.0904 *Storage.*
- 05.0905 *Transport.*
- 05.0906 *Disposal.*
- 05.0907 *Containers.*

05.1000 Management of decommissioning very low-level waste.

- 05.1001 *Characterisation.*
- 05.1002 *Treatment and packaging.*

05.1003 *Transport.*
05.1004 *Disposal.*

05.1100 Management of decommissioning very short-lived waste.

05.1101 *Characterisation.*
05.1102 *Treatment, storage, handling and packaging.*
05.1103 *Final management of decommissioning very short-lived waste.*

05.1200 Management of decommissioning exempt waste and materials.

05.1201 *Treatment and packaging.*
05.1202 *Clearance measurement of exempt waste and materials.*
05.1203 *Transport of hazardous waste.*
05.1204 *Disposal of hazardous waste at dedicated waste dumps.*
05.1205 *Transport of conventional waste and materials.*
05.1206 *Disposal of conventional waste at conventional waste dump.s*

05.1300 Management of decommissioning waste and materials generated outside controlled areas.

05.1301 *Recycling of concrete.*
05.1302 *Treatment and packaging of hazardous waste.*
05.1303 *Treatment and recycling of other materials.*
05.1304 *Transport of hazardous waste.*
05.1305 *Disposal of hazardous waste at dedicated waste dumps.*
05.1306 *Transport of conventional waste and materials.*
05.1307 *Disposal of conventional waste at conventional waste dumps.*

06 Site infrastructure and operation

06.0100 Site security and surveillance.

06.0101 *Procurement of general security equipment.*
06.0102 *Operation and maintenance of automated access control systems, monitoring systems and alarms.*
06.0103 *Security fencing and protection of remaining entrances against trespassing.*
06.0104 *Deployment of guards/security forces.*

06.0200 Site operation and maintenance.

06.0201 *Inspection and maintenance of buildings and systems.*
06.0202 *Site upkeep activities.*

06.0300 Operation of support systems.

06.0301 *Electricity supply systems.*
06.0302 *Ventilation systems.*
06.0303 *Heating, steam and lighting systems.*
06.0304 *Water supply systems.*
06.0305 *Sewage/waste water systems.*
06.0306 *Compressed air/nitrogen systems.*
06.0307 *Other systems.*

06.0400 Radiation and environmental safety monitoring.

06.0401 *Procurement and maintenance of equipment for radiation protection and environmental monitoring.*
06.0402 *Radiation protection and monitoring.*
06.0403 *Environmental protection and radiation environmental monitoring.*

07 Conventional dismantling, demolition and site restoration

07.0100 Procurement of equipment for conventional dismantling and demolition.

07.0101 Procurement of equipment for conventional dismantling and demolition.

07.0200 Dismantling of systems and building components outside the controlled area.

07.0201 Electricity generating system.
07.0202 Cooling system components.
07.0203 Other auxiliary systems.

07.0300 Demolition of buildings and structures.

07.0301 Demolition of buildings and structures from the formerly controlled area.
07.0302 Demolition of buildings and structures outside the controlled area.
07.0303 Dismantling of the stack.

07.0400 Final cleanup, landscaping and refurbishment.

07.0401 Earthworks, landworks.
07.0402 Landscaping and other site finishing activities.
07.0403 Refurbishment of buildings.

07.0500 Final radioactivity survey of site.

07.0501 Final survey.
07.0502 Independent verification of the final survey.

07.0600 Perpetuity funding/surveillance for limited or restricted release of property.

07.0601 Routine maintenance.
07.0602 Surveillance and monitoring.

08 Project management, engineering and support

08.0100 Mobilisation and preparatory work.

08.0101 Mobilisation of personnel.
08.0102 Establishment of general supporting infrastructure for decommissioning project.

08.0200 Project management.

08.0201 Core management group.
08.0202 Project implementation planning, detailed ongoing planning.
08.0203 Scheduling and cost control.
08.0204 Safety and environmental analysis, ongoing studies.
08.0205 Quality assurance and quality surveillance.
08.0206 General administration and accounting.
08.0207 Public relations and stakeholders involvement.

08.0300 Support services.

08.0301 Engineering support.
08.0302 Information system and computer support.
08.0303 Waste management support.
08.0304 Decommissioning support including chemistry, decontamination.
08.0305 Personnel management and training.
08.0306 Documentation and records control.
08.0307 Procurement, warehousing, and materials handling.
08.0308 Housing, office equipment, support services.

08.0400 Health and safety.

08.0401 Health physics.
08.0402 Industrial safety.

08.0500 Demobilisation.

08.0501 Demobilisation of project infrastructure for decommissioning.
08.0502 Demobilisation of personnel.

08.0600 Mobilisation and preparatory work by contractors (if needed).

08.0601 Mobilisation of personnel.
08.0602 Establishment of general supporting infrastructure for decommissioning project.

08.0700 Project management by contractors (if needed).

08.0701 Core management group.
08.0702 Project implementation planning, detailed ongoing planning.
08.0703 Scheduling and cost control.
08.0704 Safety and environmental analysis, ongoing studies.
08.0705 Quality assurance and quality surveillance.
08.0706 General administration and accounting.
08.0707 Public relations and stakeholder involvement.

08.0800 Support services by contractors (if needed).

08.0801 Engineering support.
08.0802 Information system and computer support.
08.0803 Waste management support.
08.0804 Decommissioning support including chemistry, decontamination.
08.0805 Personal management and training.
08.0806 Documentation and records control.
08.0807 Procurement, warehousing, and materials handling.
08.0808 Housing, office equipment, support services.

08.0900 Health and safety by contractors (if needed).

08.0901 Health physics.
08.0902 Industrial safety.

08.1000 Demobilisation by contractors (if needed).

08.1001 Demobilisation of project infrastructure for decommissioning.
08.1002 Demobilisation of personnel.

09 Research and development

09.0100 Research and development of equipment, techniques and procedures.

09.0101 Equipment, techniques and procedures for characterisation.
09.0102 Equipment, techniques and procedures for decontamination.
09.0103 Equipment, techniques and procedures for dismantling.
09.0104 Equipment, techniques and procedures for waste management.
09.0105 Other research and development activities.

09.0200 Simulation of complicated works.

09.0201 Physical mock-ups and training.
09.0202 Test or demonstration programmes.
09.0203 Computer simulations, visualisations and 3D modelling.
09.0204 Other activities

10 Fuel and nuclear material

10.0100 Removal of fuel or nuclear material from facility to be decommissioned.

10.0101 Transfer of fuel or nuclear material to external storage or to treatment facilities.
10.0102 Transfer of fuel or nuclear material to dedicated buffer storage.

10.0200 Dedicated buffer storage for fuel and/or nuclear material.

- 10.0201 *Construction of buffer storage.*
- 10.0202 *Operation of buffer storage.*
- 10.0203 *Transfer of fuel and/or nuclear material away from the buffer storage.*

10.0300 Decommissioning of buffer storage.

- 10.0301 *Decommissioning of buffer storage.*
- 10.0302 *Management of waste.*

11 Miscellaneous expenditures

11.0100 Owner costs.

- 11.0101 *Implementation of transition plans.*
- 11.0102 *External projects to be performed as a consequence of decommissioning.*
- 11.0103 *Payments (fees) to authorities.*
- 11.0104 *Specific external services and payments.*

11.0200 Taxes.

- 11.0201 *Value added taxes.*
- 11.0202 *Local, community, federal taxes.*
- 11.0203 *Environmental taxes.*
- 11.0204 *Taxes on industrial activities.*
- 11.0205 *Other taxes.*

11.0300 Insurances.

- 11.0301 *Nuclear related insurances.*
- 11.0302 *Other insurances.*

11.0400 Asset recovery.

- 11.0401 *Asset recovery related to redundant equipment.*
- 11.0402 *Asset recovery related to released materials.*
- 11.0403 *Asset recovery related to material and equipment from conventional dismantling and demolition.*
- 11.0404 *Asset recovery related to buildings and site.*
- 11.0405 *Other asset recovery.*

Appendix B: List of assumptions and boundary conditions in decommissioning costing

The following detailed list of assumptions and boundary conditions is intended as guidance to users concerning the completeness of the scope of work to be included in the cost estimate. The assumptions and boundary conditions are grouped according to similar activities and decommissioning phases. The purpose is to address specific work activities in each phase to ensure that all elements of the estimate are properly covered.

A. Engineering and planning

1. Pre-shutdown activities:

   - Strategy selection.
   - Shutdown date.
   - Safe enclosure period duration.
   - Facility characterisation for planning.
   - Engineering and planning assumptions for equipment disposition.
   - Waste management planning.
   - Safety planning.
   - Preparation of final decommissioning plan (DP) assumption.
   - Preparation of environmental report (ER) assumption.
   - Preparation of full list of documents for licensing.
   - Timing for submittal of DP, ER and other documents to regulator(s).
   - Timing and preparation of updated cost estimate and schedule.
   - Preliminary site characterisation planning assumptions.

2. Planning for non-standard cases:

   - Evaluation of impact of events/accidents.
   - Assessment of impact on safety on site and environment.
   - Engineering and planning assumptions for ensuring safety on site and in environment.
   - Engineering and planning assumptions for remediation.
   - Engineering and planning assumptions for dismantling.
   - Engineering and planning assumptions for waste management.

3. Transition planning:

   - Identification of key employees to be retained.
   - Retention plans for key employees.
   - Severance plans for redundant employees.
   - Detailed planning of sequential shutdown/modification of systems.
   - Procurement of decommissioning operations contractor (DOC).
   - Mobilisation of DOC: when and estimated costs.

4. Detailed engineering and planning:

   - Detailed sequencing of the work assumptions of timing and sequence.
   - Preparation of activity specifications (work plans) – utility or DOC work.
   - Preparation of detailed procedures – DOC work.
   - Modification of existing operational technical specifications – utility work.
   - Modification of QA programme and QA programme procedures – utility work.

5. Site characterisation:

   - Preparation of the site characterisation plan – utility work.
   - Performing the site characterisation – utility or special contractor work.

6. Site preparations:

   - Identification of drain-down, lock-out, tag-out of redundant systems.
   - Identification for procurement of long-lead and specialised equipment.
   - Identification of items for sale of reusable redundant equipment.
   - Identification of modification of site security provisions for decommissioning.

7. Project management:

   - Identification of utility staff personnel functional positions.
   - Preparation of project management manual – utility work.
   - Establishment of a project cost and schedule programme – utility and DOC work.
   - Assignment and agreement of responsibilities between utility and DOC staff.

B. Termination of operation and spent fuel management

1. Spent fuel and nuclear material management:

   - Cooling down of spent fuel.
   - Transfer of fuel to the fuel storage pool – assumptions on timing and capacity.
   - Procurement of dry cask canisters – type of canisters and vendor.
   - Construction of an independent spent fuel storage installation (ISFSI).
   - Identification of installation of spent fuel storage security measures.
   - Management of damaged spent fuel.
   - Management of nuclear materials in fuel cycle facilities.

2. Systems and infrastructure:

   - Preparation of primary systems for decommissioning.
   - Sequential modification/shutdown of auxiliary systems.
   - Preparation of decommissioning infrastructure.

3. Operational fluids/waste/materials management:

   - Removal/processing of operational waste.
   - Removal of redundant equipment and materials.

4. Funding for transition period:

    - Assumptions for activities paid from decommissioning fund.
    - Assumptions for activities paid from other funds.

C. Safe enclosure preparation and operation

1. Preparation of safe enclosure:

    - Preparation/modification of the controlled area.
    - Preparation of systems and structures for safe enclosure.
    - Site modification.

2. Operation of safe enclosure

    - Care and maintenance.
    - Surveillance and security.
    - Inspections.
    - Capital maintenance.

D. Decontamination and dismantling

1. Procurement of equipment for decontamination and dismantling:

    - Procurement of equipment for standard decontamination and dismantling.
    - Procurement of equipment for post-accidental scenarios and other nonstandard scenarios.

2. System decontamination:

    - Decontaminate portions of primary coolant system.
    - Decontamination of large open systems in reactor facilities and in non-reactor facilities.
    - Drainage of remained open systems.
    - Decontamination of large open systems in reactor facilities and in non-reactor facilities.
    - Removal/remediation of asbestos/hazardous materials from systems and structures.
    - Removal of sludge and decontamination in fuel cycle facilities.

3. Reactor vessel and internals, main systems in non-nuclear facilities:

    - Reactor internals segmentation size and disposition method assumption.
    - Reactor vessel one-piece vs. segmented removal assumption.
    - Dismantling approaches for research reactors.
    - Method of transport and disposal assumption.
    - Dismantling methods for main processing systems in non-reactor facilities.
    - Dismantling methods for biological shielding.
    - Dismantling methods in systems after accidents.

4. Steam generators and pressurisers:

    - One-piece vs. segmented removal assumption.
    - Grouting of component interior assumption.
    - Method of transport and disposal assumption.

5. Reactor coolant (PWR) pumps and recirculation (BWR) pumps:

   - One-piece vs. segmented removal.
   - Method of transport and disposal.

6. Turbine-generators:

   - Sale or scrap of turbine-generator assumption.
   - Method of transport and disposal assumption.

E. Licence termination activities

1. Building and structure decontamination:

   - Mechanical decontamination vs. total removal assumption.
   - Bulk material transfer or container packaged assumption.
   - Contaminated soils removal assumptions.
   - Underground water remediation assumptions.

2. Site release criteria:

   - Determination of legal criteria for regulators and stakeholders assumption.
   - Disposition of non-radioactive material assumption.

3. Final site termination survey:

   - Assumption of utility staff or outside contractor.

4. Re-release of site

   - Assumption for restricted release of the site.
   - Assumptions for site operation during restricted release of the site.
   - Assumptions for termination of restricted release of the site.

F. Dismantling and demolition outside controlled area

1. Balance of plant equipment:

   - Sale or scrap of equipment assumption.
   - Method of transport and disposal assumption.

2. Building demolition:

   - Assumption of DOC work or outside demolition contractor.
   - Disposition of material as bulk transfer, or on-site use as fill.
   - Assumption of demolition to grade or below grade.

3. Infrastructure demolition:

   - Assumption of possible reuse for replacement facility.
   - Assumption of complete demolition to below grade.

4. Site restoration:

   - Assumption of greenfield or brownfield.
   - Disposition of below-grade structures (base mats).

G. Waste management

1. Operational/historical/legacy waste:

   - Assumptions for management of operational/historical/legacy wastes.
   - Estimated costs for operational/historical/legacy waste.

2. Waste management system:

   - Assumptions for inventory of all classes/types of waste.
   - Assumptions for overall waste management system.
   - Assumptions for own waste management system.
   - Assumptions for shared waste management systems and services.
   - Estimated costs for establishment of own waste management system.
   - Estimated costs for shared waste management systems and services.
   - Assumptions for postponed waste management.

3. Conditioning and packaging:

   - Assumptions of types of containers and casks.
   - Assumptions of grouting or non-grouting of containers for disposal.
   - Estimated costs for packaging.

4. Transportation:

   - Assumptions of various types of waste for truck, rail or barge shipment.
   - Estimated costs for transportation by each mode.

5. Disposal:

   - Assumptions regarding ultimate disposal or on-site or off-site storage.
   - Estimated costs for disposal or storage.

6. Waste processing:

   - Assumptions regarding use of on-site or off-site reprocessor.
   - Assumptions of the amount and types of materials to be reprocessed.

7. Releasing of materials:

   - Assumptions for unconditional release of materials.
   - Assumptions for conditional release of materials.

8. Recycling:

   - Assumptions regarding clean material recycling.
   - Assumptions of value of recycled materials.

9. Scrap/salvage:

   - Assumptions of the types and quantities of materials for scrap/salvage.
   - Assumptions of value of scrap/salvage material.

H. Entombment cases

1. Preparation of final entombment state:

   - Assumptions for final entombment state in systems and structures.
   - Methods for verification of final entombment state.

I. Research and development for decommissioning projects

1. Research and developments:

   - Assumptions for R&D for characterisation, decontamination and dismantling.
   - Assumptions for R&D for waste management.
   - Assumptions for R&D for accidental cases to ensure safety.
   - Estimated costs for R&D activities.

2. Simulations and training:

   - Assumptions for computer simulations, visualisations and virtual reality.
   - Assumptions for specialised training.
   - Estimated costs for simulations and training services.

J. Management schemes for decommissioning projects

1. Management schemes:

   - Management and support by own personnel.
   - Management and support by general contractor.
   - Management and support by multi-contractor scheme.
   - Assumptions for cost data for contractors.

K. Other costs related to decommissioning

1. Other costs:

   - Assumptions for other costs related to transition period.
   - Assumptions for other costs related to external payments.
   - Assumptions for taxes, insurances and interests.
   - Assumptions for assets.

Appendix C: Quality assurance and contingency

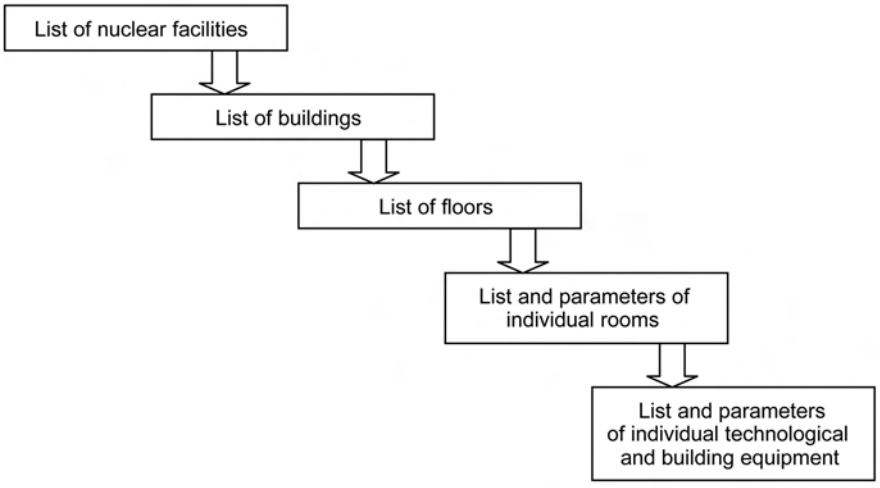
C.1 Quality assurance and traceability of data

C.1.1 Guidance for a cost estimating QA system

The point of departure for a decommissioning cost estimate is the existing or planned infrastructure for decommissioning. The calculation options should cover all relevant scenarios (e.g. immediate or deferred decommissioning strategy combined with relevant options for waste treatment). The options are then developed based on the decommissioning inventory database and the extent of the decommissioning activities anticipated for the relevant calculation option. The main sources of data for the cost estimate are the facility inventory data and specific calculation data – see below.

The general structure of the facility inventory database should correspond to the costing approach. In any decommissioning project, the decontamination and dismantling activities are performed in a repetitive manner, e.g. organised room by room or system by system. In order to be able to implement this approach, e.g. to evaluate the costs at the level of individual buildings, and in order to be able to identify all relevant decommissioning activities, the facility inventory database should have the basic structure presented in the figure below.

General structure of the facility inventory database



The inventory database typically incorporates the following categories of data:

- Identification data:

  Identification data are needed for implementation of a room-oriented or system-oriented dismantling approach. Allocation of data to technical systems facilitates

the definition of radiological parameters for the individual inventory items. As well as creating a linkage between the facility inventory database and the ISDC, data items may be allocated to:

a) allocation to structures (building, floor, room); and

b) allocation to systems (e.g. primary loop system).

- Physical data such as mass, surface areas, volumes, which are used as input variables. Physical data may be prepared by review of technical documentation (project and operational documentation), historical data (operational records), by inspections on site, or based on the experience of operation personnel.
- Radiological data – contamination levels of internal and external surfaces, activation of reactor components and the biological shield, mass activity, depth of contamination/activation for infrastructures, and the relevant composition of radionuclides.
- Decommissioning data – decommissioning categories of equipment within the rooms, which are used for the calculation of decommissioning parameters. Categorisation requires the development of a list of representative equipment, building surfaces, items of structures for which the unit factors are prepared and used for the calculation of decommissioning parameters. Each category may then be used for a group of equipment with similar properties, thus reducing the number of unit factors and other parameters needed for decommissioning costing.

Individual decommissioning activities in the cost model are represented by mathematical calculation procedures which, except for facility inventory data, require a set of common calculation data with a broad spectrum of parameters. Parameters describing features of a decommissioning activity such as the yield/capacity of different decommissioning techniques, rates of consumption of various media and materials used, working group composition (number of workers and their professions), cost parameters (wages of workers, cost unit factors of consumed media and materials).

The database containing this data comprises unit factors and other calculation data in the form of specific parameters and constants. These data are the second main source of input data for the cost estimate. They include the input data specific to the decommissioning project, which are normally used as common data for the project as a whole. These data describe the activities which are carried out during the decommissioning process. The database of unit factors can be divided into the following main groups according to the character of the data:

- general calculation data – material and media (e.g. water, steam, gas) cost unit factors, personnel specific data and other overall data not depending of specific decommissioning activities;
- calculation data specific for decommissioning activities – parameters of techniques and processes (manpower, cost, media consumption unit factors), working group data;
- work difficulty factors;
- waste data; and
- local input data specific for individual calculation items.

It is convenient to organise the data for individual decommissioning (and waste management) techniques in the form of data sheets corresponding to each specific technique.

C.1.2 Development and maintenance of data traceability

Sources of data

The level of accuracy of a decommissioning cost estimate is highly dependent on the quality of the input data. The data may be divided into two groups:

- the inventory database; and
- the unit factors and coefficients database.

Records for the first group can be obtained from design documentation, on-site measurement and operational knowledge of staff.

The unit factors and coefficient database may be established based on experience from similar ongoing project or projects performed in the past, from industrial norms or non-nuclear projects adjusted for the nuclear area, from scientific literature, and from operational records.

Regular updates, record keeping, data protection

For the purposes of decommissioning it is necessary to keep available all relevant information about the nuclear installation to be decommissioned. This requirement applies equally to small nuclear installations (research reactors, medical or nuclear devices) as to nuclear power plants. After final shutdown there is a tendency for the amount of readily-available information about a nuclear facility to decrease, e.g. operational staff may be moved to other facilities and their detailed knowledge lost. In certain cases, the record systems maintained during the operational period (design documentation, operational regulations and records, minutes of working meetings and manuals) may be lost.

To avoid the problems noted above, it is good practice to create a system for collection and sorting of relevant information and a system for storing and retrieval of this information. Such systems are generally referred to as RCMS (record collection and management systems).

The main data necessary for decommissioning can be divided into three basic areas:

- data on construction and renovation of the nuclear installation;
- data on operation of the installation; and
- data on shutdown of the installation and on its condition after shutdown.

Data concerning the construction and renovation of an installation are generally created during the design, construction and operating phases (maintenance, revision, retrofitting). These data may include:

- data about characteristics of the location in which nuclear installation is established, geological and radiological characterisation of the environment;
- complex design documentation for the installation, buildings and technical equipment including necessary material and building calculations;
- detailed photo documentation of individual parts of the installation;
- records about amount and type of used structural materials;
- characterisation of technical devices from a structural materials point of view;
- certificate of quality;
- safety analysis of emergency situations in the installation;
- characterisation of influence of the nuclear installation on the environment;

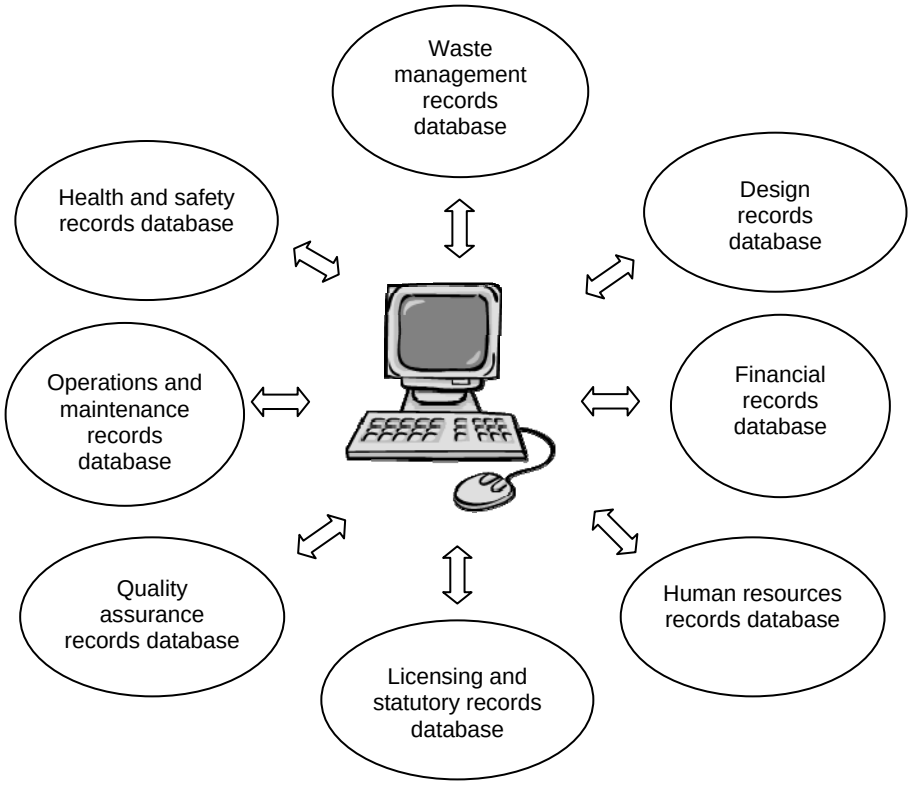
- documentation about the tests of the installation before commencing the operation;
- documents related to the process of obtaining a licence for operation; and
- preliminary decommissioning plan for the installation.

Data concerning the operation of the installation are obtained during that phase and comprise:

- requirements for obtaining the licence for operation and maintaining the licence;
- safety analysis;
- operational regulations and manuals;
- data on the radiation situation in the installation and in its surroundings;
- operational and service records;
- records on non-standard conditions of the installation and individual technical units;
- plans for potential decontamination and protocols about its performance;
- technical specifications and limits;
- documentation about performed changes and interferences with the building and technical part of the nuclear installation;
- inventory of dangerous materials located within the installation;
- connection to and influence on surrounding nuclear or non-nuclear installations;
- records about performed inspections and controls together with their evaluation;
- records on radioactive waste management;
- records on termination of operation of the nuclear installation and of individual technical devices during the operation and after shutdown of the nuclear installation;
- records on quality system;
- information about neutron flux and its distribution during operation;
- information about radiation sources and their location in the surrounding of the installation;
- documentation about accidents and leakages;
- records on irradiation of structural materials; and
- results of laboratory tests influencing the decommissioning process.

In general, each decommissioning project is supported by a large amount of different data, which may conveniently be organised into a number of categories. An integrated information system enables different data items to be interconnected. A schematic representation of such a system is shown in the figure below.

Integrated information system for RCMS



The RCMS is a system for collection, categorisation, maintenance and distribution of data records, which must be installed according to designated procedures, in compliance with the quality system for the project. A primary goal of the RCMS is to provide relevant records to support decommissioning planning and to verify the suitability of the data sources. It includes also storage of necessary information needed for the period of institutional control and, if necessary, beyond this period.

To meet the above mentioned requirements the system has to provide for:

- identification of records together with verifying the data source;
- transfer, delivery and acceptance of records;
- index of stored records;
- storage of categorised records;
- checking of individual records management;
- checking of history of record changes;
- regular data transfer between different storage media; and
- national and international archival requirements.

Records may currently be stored and protected using different media:

- Printed, paper form – an advantage of this form is that it is usually the original record, it is easy to create copies, and changes are easily identified. The

disadvantages are that a large space is necessary for storage, and records may easily be lost.

- Microfilm – an advantage of this form is that they are easily stored, it is easy to create copies, and changes are easily identified. The disadvantages are mainly that a large volume of media is required for storage of large amounts of information, they can be easily lost, and difficulty in creating paper copies.
- Magnetic tapes and discs – the advantage of this form is simple and compact storage, the recorded data are not affected by copying, and there is a possibility of easy updating. The disadvantages of these media are: they may degrade in the event of physical or magnetic damage, materials in paper form must be scanned in order to be stored in this form, and regular update of hardware and software is necessary as the result of technical advances.
- Optical and compact disks and digital video disks – the advantage of this form is simple and compact storage, the recorded data are not affected by copying, simple and prompt access to data. The disadvantages of these media are that materials in paper form must be scanned to be stored in this form and regular update of hardware and software is necessary as a result of technical advances.

The system of collection, classification, storing and management of information is highly demanding of operator resources, reflecting its importance during the decommissioning process.

Regular updates should be made on a periodical basis; each data record as hard copy or electronic copy should contain information about necessary periodical updates. Updates should be performed by reaching the original reference source or by finding another source of data and by noting the performance of the update procedure directly on the updated or verified records.

Data feedback from decommissioning

An important aspect of decommissioning cost control is to update the cost estimate taking account of updated project specific input data. Periodical update of decommissioning data is one of the IAEA recommendations for cost control – TECDOC 1476 “Financial Aspects of Decommissioning” [3]. An effective approach to the updating of input data used for decommissioning costing is the implementation of a data feedback system using data which are collected and evaluated during ongoing decommissioning projects.

Data feedback is a general requirement for any decommissioning costing model, and costing models typically use their own specific structures. The systems and methodologies for data feedback tracking should correspond to these specific structures.

As discussed in Chapter 4, the cost model may be based directly on the ISDC or, alternatively, it may be based on the WBS used for project management. In the latter case the estimated costs need to be converted to the ISDC. An important advantage of the former approach is to facilitate the development of a systematic approach to collecting, analysing and upgrading representative costing input data which can be used for decommissioning costing in the next decommissioning projects for similar facilities or in the context of an ongoing decommissioning project in order to improve the quality of planning data for the remaining phases of that project. Periodical updating of cost is an essential element in decommissioning costing.

Types of data required for decommissioning costing include the following:

1) List of decommissioning activities according to the decommissioning plan.
2) Facility inventory data – systems, structures, radiological data, other data.

3) Unit factors, increase factors and other calculation data used in calculation of cost, manpower, exposure and other data. These data should be developed for all types of decommissioning activities and for all types of inventories and working constraints involved in the project. These data are subject of data feedback in costing.

Data feedback in decommissioning costing is based on collection of representative data from decommissioning processes, comparison of these data with the data calculated for the project and analysis of differences between the calculated and measured data. The aim is to identify the differences, find out reasons for differences and modify the specific input data used in calculation of cost and other parameters. Data feedback in costing based on the ISDC requires the management of collected data according to the ISDC structure. Due to the large extent of decommissioning activities, grading is introduced into the data feedback system. In the ISDC costing approach, two alternative levels of data collection are considered:

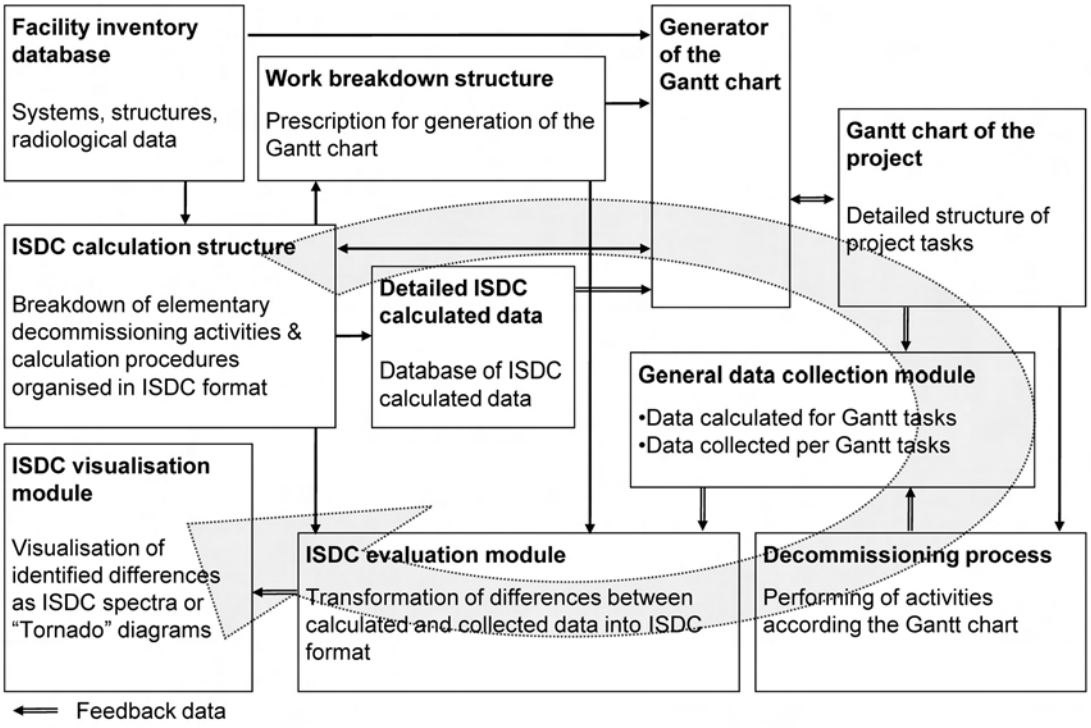
1) Collecting and comparing selected general data (see figure below)
   - data are collected and compared at the level of tasks of the Gantt chart;
   - results are formatted according to the ISDC; and
   - data feedback at this level has an informative character for visualisation of identified differences between the calculated and measured data.

A purpose of this approach is to develop a global overview of differences between calculated and measured data for the whole decommissioning project. Data are collected and analysed according to tasks of the Gantt chart. Data should be available for comparison with other projects; they are converted to the ISDC as a general platform for decommissioning costing. Differences may also be visualised in ISDC spectra at three levels using "tornado" diagrams to distinguish the scale of differences. ISDC spectra are graphs/histograms of values for individual ISDC Activity Groups/Typical Activities.

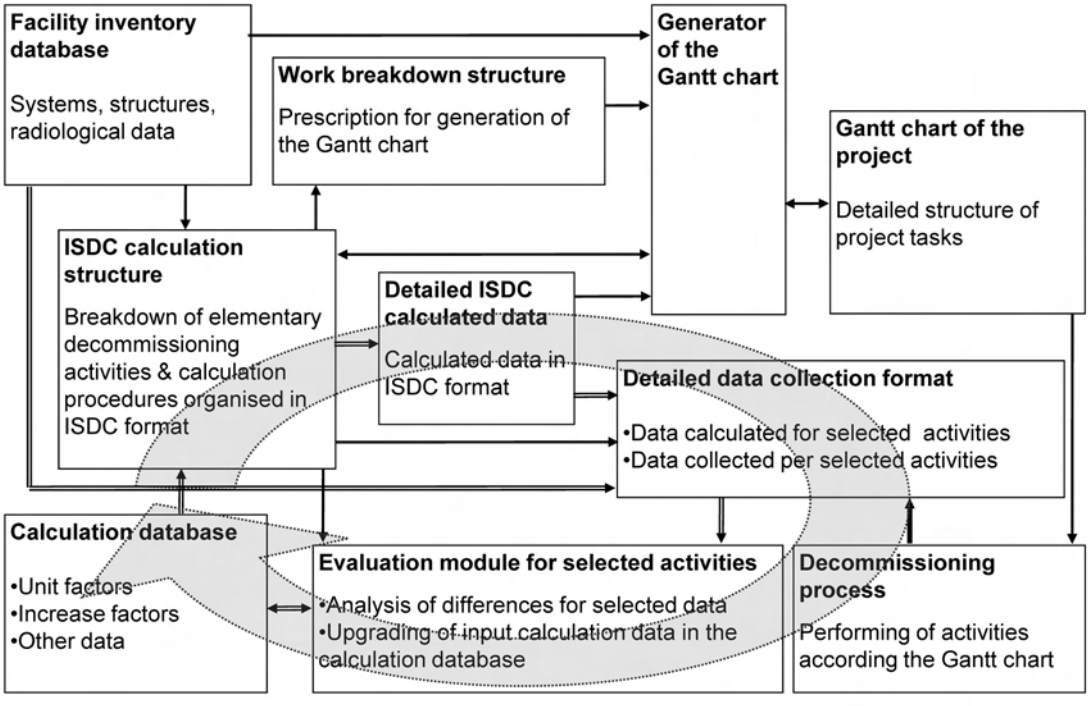
2) Analysis of detailed data collected for representative activities (see figure below)
   - data feedback covers specific types of decommissioning activities involved in the project;
   - selected representative data are collected and analysed; and
   - data are used for updating of specific calculation data for individual techniques.

This approach facilitates the accumulation of data for representative inventory-dependent decommissioning activities occurring in the project. The collection of data for these activities is an additional task to the planned project work. Results are used for updating of specific data such as unit factors, work difficulty factors and other data used for calculation of parameters for individual techniques.

Collecting and comparing selected general data



Analysis of detailed data collected for representative activities



C.2 Applying contingency to decommissioning cost estimates

C.2.1 Contingency definition

Contingencies may be defined as "specific provisions for unforeseeable elements of cost within the defined project scope" [2, 11]. As costs are generally calculated in the first instance on the basis of standard conditions and mean efficiencies of activities, the contingency factor ensures that the estimate is realistic. It should be noted that contingency does not account for price escalation and inflation in the cost of decommissioning over the remaining operating life of the nuclear installation.

Contingency also includes an allowance for indeterminate elements and should be related to the level of design, degree of technological advancement, and the quality/reliability pricing level of given components. Contingency does not include any allowance for potential changes from external factors, such as changing government regulations, major design changes or project scope changes, catastrophic events (force majeure), labour strikes, extreme weather conditions (e.g. floods, extreme frosts), varying site conditions, or project funding (financial) limitations.

C.2.2 Methods of contingency calculation

As decommissioning planning may begin a few decades in advance, the calculated cost items are influenced by significant levels of uncertainty. Cost uncertainties are determined from a set of input data, e.g. physical, radiological, decommissioning process, and economic parameters. These uncertainties are typically estimated using expert judgment or through comparison with similar decommissioning projects.

In general, the sources of inaccuracy that influence decommissioning costs can be distinguished according to the following groups:

- uncertainties of input parameters – uncertainties are linked to particular input calculation parameters;
- uncertainties related to the extent of decommissioning activities – the assumed extent of decommissioning activities may be too limited, in particular for highly contaminated or activated systems and equipment with complex structures, such as a reactor and its inner parts or auxiliary reactor systems. In these cases some decommissioning activities have to be repeated or applied to a greater extent than originally planned; and
- the nature of documents for which evaluation of decommissioning cost is performed – in general, a preliminary cost evaluation can be calculated for decommissioning documents that outline a conceptual decommissioning plan. Such a calculation is based on a simple inventory database and other input parameters, and therefore the level of contingencies needs to be appropriately large. The documentation used to support the implementation of decommissioning plans is based on a detailed inventory database and other input parameters for cost calculation. Values of contingencies can be lower in this case, since the higher accuracy of calculated costs for decommissioning is assumed.

An alternative approach to evaluating contingency is based on an analytical evaluation of the impact of input data uncertainties on the cost and other output parameters (exposure, labour, amount of radioactive waste etc.). The contingency methodology is applied to ISDC items from Level 3 (Typical Activities) downwards. At the 1st and 2nd levels contingencies represent a summation of the contingencies at Level 3.

The proposed methodology is based on the fact that the calculated costs are available during execution of the calculation in a detailed structure. The costs are recorded in an output data table. The basis of the methodology is an application of contingency for each

decommissioning activity. The value of a contingency item is based on the application of a set of correction factors on particular costs – labour cost, investments and expenses. This procedure leads to the identification of a margin of reserve for each cost items.

C.2.3 Implementation of contingency

To eliminate the impact of uncertainties in input parameters several approaches may be used to take account of contingency:

- contingency application for an entire decommissioning project;
- contingency application for groups of decommissioning activities; and
- contingency application for individual decommissioning activities.

■ Contingency application for an entire decommissioning project

The simplest approach is to apply a single contingency allowance to an entire decommissioning project. Here, the contingency is estimated on the basis of expert judgement or by means of other methods as a percentage of the total cost of the decommissioning [2]. This methodology is based on the practical experience of the estimator and the contingency can contain significant uncertainties. This approach is also widely used because of lack of analytical methods for contingency estimation. Typical contingency levels may range from -5% to +15% for detailed cost estimates made at the outset of decommissioning projects, to -15% to +30% for preliminary cost estimates [2].

■ Contingency application for groups of decommissioning activities

Another approach to address the impact of input parameter uncertainty is the application of contingency provisions to a specific group of activities. This approach reflects the fact that different uncertainties in input data can be identified for different groups of activities in the decommissioning process. These uncertainties may also have different weight of influence.

Following this approach individual activity contingencies may range from 10% to 75%, depending on the degree of difficulty judged to be appropriate by the cost estimator [2, 11]. The contingencies also depend on the accuracy of the inventory and of the site characterisation/mapping (linked to the status of the decommissioning).

■ Contingency application for individual decommissioning activities

The most detailed approach to the issue of the impact of uncertainties of input parameters is the application of contingency directly for each activity during the calculation of decommissioning costs according to the ISDC. For each individual activity contingency can be applied by three sub-cost contingencies: for labour, investment and expenses. This approach ensures consideration of individual conditions and characteristics of specific decommissioning activities. The approach is applied in the methodology for contingency estimation on the basis of analytical procedures.

Appendix D: Standardised definitions for cost items

01 PRE-DECOMMISSIONING ACTIONS

Principal Activity 01 comprises activities carried out during the preparation for licensing of decommissioning or for equivalent regulatory approvals. It is subdivided into six Activity Groups:

- Decommissioning planning.
- Facility characterisation.
- Safety, security and environmental studies.
- Waste management planning.
- Authorisation.
- Preparing management group and contracting.

01.0100 Decommissioning planning

01.0101 Strategic planning

- Evaluation and approval of decommissioning options:
  - Consideration and evaluation of available internal/external facilities.
  - Consideration of the risk inherent in acceleration or deferral in proposed alternative.
  - Consideration of cost, time and personnel capacity.
  - Consideration of available funding.
- Evaluation and approval of reuse of facilities.
- Consideration of the cost to isolate, protect and maintain such facilities throughout the decommissioning process.

01.0102 Preliminary planning

- Preparation of preliminary decommissioning plan.
- Collection of documentation on the facility.
  - Inventory of the active and non-active equipment to be dismantled.
  - Evaluation of expected radiological state.
- Proposal for a decommissioning strategy and a scenario including:
  - Inventory of dismantling activities.
  - Inventory of active and non-active waste production and waste routing.
- Preliminary estimate of decommissioning work to be carried out including:
  - Estimation of personnel requirements.
  - Estimation of occupational dose.
  - Scheduling of activities.
  - First estimate of decommissioning costs.

01.0103 Final planning

- Preparation of final decommissioning plan.
- Review of final decommissioning scenario including:
  - Detailed inventory of dismantling activities.
  - Detailed inventory of active and non-active waste production.
  - Consideration of funding requirements.

  - Consideration of the risk inherent in acceleration or deferral in proposed alternative.
- Detailed estimate of decommissioning work to be carried out, including:
  - Personnel requirements.
  - Required equipment, tooling, waste management facilities.
  - Occupational dose.
  - Planning of activities.
  - Final cost estimate for decommissioning operations.
- Preparation of staffing transition plan:
  - Staff redeployment.
  - Re-assignment/training.
  - Key employee retention/incentive programmes, etc.

01.0200 Facility characterisation

01.0201 Detailed facility characterisation

- Centralisation of existing documentation.
- Determination of the radionuclide inventory in the facility to be decommissioned as well as in the surrounding environment, by:
  - Radionuclide modelling.
  - Direct measurements.
  - Sampling.
  - Radiochemical analysis.
- Characterisation for decontamination through:
  - Base-material identification.
  - Process-fluid chemistry.
  - Corrosion-film analysis.
  - Residuals, etc.
- Detailed compilation of the active and non-active equipment to be dismantled.
- Documentation of the current radiological state by detailed dose-rate measurements, contamination measurements, sampling, radiological calculations, etc.

01.0202 Hazardous-material surveys and analyses

- Chemical, explosive, flammable material surveys and analysis, to be carried out for the radioactive and the conventional parts of the buildings.

01.0203 Establishing a facility inventory database

- Acquiring database, entering data.

01.0300 Safety, security and environmental studies

01.0301 Decommissioning safety analysis

- Safety analysis, involving:
  - Shutdown of the facility.
  - Decommissioning activities.
  - End state.
  - Safe enclosure (if relevant).
  - Conventional hazards.

01.0302 Environmental impact assessment

- Preparation of environmental impact assessment report

01.0303 Safety, security and emergency planning for site operations

- Contingency planning for emergency.
- Assessment of physical protection needs, including re-fencing.

01.0400 Waste management planning

01.0401 Establish waste management criteria

- Decontamination.
- Disposal.
- Clearance/release.
- Recycling.

01.0402 Develop a waste management plan

- Identification of waste management systems.
- Determination of the impact of release criteria on decontamination and dismantling methods.
- Establish packaging and containers concept (including conditioning).

01.0500 Authorisation

01.0501 Licence applications and licence approvals

- Regulatory assessment/compliance and permits.
- Preparation and revision of technical and operating specifications as to gain regulatory and financial relief effective upon facility shutdown, such as approval(s) to reduce or eliminate:
  - Operating fees.
  - Insurance premiums.
  - Testing and maintenance requirements.
  - Staff positions.
  - Training programmes.
  - Security provisions.
  - Safety systems reconfiguration.
  - Non-essential system disposition, etc.
- Licence applications, licence documentation, environmental compatibility assessment.
- Appraisal of the documentation provided by the applicant through an expert consultant appointed by the authority.
- Discussions with legal authorities.
- Expenditures incurred by the authority in processing the licence.
- Operation and maintenance procedures.

01.0502 Stakeholder involvement

- Public information.
- Public inquiries.
- Public consultations.
- Public hearings.
- Neighbouring countries.
- Consideration of the results of stakeholder involvement.

01.0600 Preparing management group and contracting

01.0601 Management team activities

- Management options, including:
  - Evaluation of approaches, ranging from project management by licensee to use of a prime contractor.
  - Consideration of available resources and options.

01.0602 Contracting activities

- Identification of companies interested in making a tender for decommissioning operations.
- Drafting tender specifications
- Qualification of companies interested in making a tender by auditing their:
  - Quality systems.
  - Technical capability.
- Technical and financial analysis of tenders of candidate prime contractors.
- Examination of capability and acceptance of subcontractors.
- Final selection of prime contractor and signing of contract.

02 FACILITY SHUTDOWN ACTIVITIES

Principal Activity 02 comprises all activities relating to shutdown operations of the facility. It has the following five Activity Groups:

- Plant shutdown and inspection.
- Drainage and drying of systems.
- Decontamination of closed systems for dose reduction.
- Radiological inventory characterisation to support detailed planning.
- Removal of system fluids, operational waste and redundant material.

02.0100 Plant shutdown and inspection

02.0101 Termination of operation, plant stabilisation, isolation and inspection

- General operations involved in:
  - Shutdown.
  - Preservation and surveillance measures to ensure nuclear safety.

02.0102 Defueling and transfer of fuel to spent-fuel storage

- Complete unloading of spent fuel.
- Transfer of spent fuel to the spent fuel pool, using equipment available during normal reactor operations.
- Management of unused fuel.

02.0103 Cooling down of spent fuel

- Operation and maintenance of required systems (e.g. water cleaning systems, heat removal, vent systems).

02.0104 Management of fuel, fissile and other nuclear materials

- Recovery of nuclear materials to balance the nuclear material inventory, including safeguards provisions.
- Application of normal operating procedures of the facility, provided the cost of the operations is financially advantageous in terms of the quantity of material recovered.
- Use of specific procedures or techniques with the possible addition of special reagents.
- On completion of these operations, a decontamination phase may be entered, as indicated in item 02.0300.

02.0105 Isolation of power equipment

- Isolation of power generating equipment.
- Disconnecting power generating equipment from the grid.

02.0106 Facility reuse

- Identification, isolation and conservation of systems and utilities to be reused
- Systems to be excluded from the decommissioning scope due to "value" in the reuse or future use of the site, such as:
  - Site general services.
  - Road and utility network infrastructure.
  - Facilities, etc.

02.0200 Drainage and drying of systems

02.0201 Drainage and drying of closed systems not in operation

- Drainage and drying of systems no longer in operation (not including processing of liquids and waste, which is treated under Principal Activity 05).

02.0202 Drainage of spent-fuel pool and other open systems not in operation

- Drainage of open pools having contained contaminated fluids.
- Design, construction and setting up additional purification equipment to allow the discharge of liquids.
- Carrying-out of radiological surveillance analyses as draining proceeds.
- Decontamination of surfaces, depending upon the pool's surface characteristics (*e.g.* coated, painted or steel-lined) and the ultimate disposition of the pool.

02.0203 Removal of sludge and products from open systems

- Removal of sludge at the bottom of pool, pit or tank.
- Removal of remaining spent fuel, residuals and special objects found in pools or pits.
- Nuclear material inventory recovery.
- Decontamination of surfaces after removal.

02.0204 Drainage of special process fluids

- Drainage of special process fluids (e.g. sodium, heavy water).

02.0300 Decontamination of closed systems for dose reduction

02.0301 Decontamination of process installations using operational procedures

- Normal decontamination with the existing systems of the facility.
- Decontamination of the process installations to reduce exposure rates, using more aggressive reagents than those applied during normal operation, keeping characteristics of used effluents compatible with technical specifications for operation on site, and including:
  - Technical process studies.
  - Equipment construction or delivery.
  - Utilisation of the system.
  - Subsequent decommissioning of the system.

02.0302 Decontamination of process installations using additional procedures

- Hard decontamination with specific process.
- Decontamination of the process installations to reduce exposure rates, using special techniques, including:
  - Technical process studies.
  - Equipment construction or delivery.
  - Utilisation of the system.
  - Subsequent decommissioning of the system.

02.0400 Radiological inventory characterisation to support detailed planning

02.0401 Radiological inventory characterisation

- Non-destructive and destructive sampling for radiological characterisation of equipment and surfaces in the facilities.
- *In situ* measurements of samples.
- Modelling, using design codes, according to reactor operating parameters (flux curves, operating time etc.)

02.0402 Underground water monitoring

- Soil sampling and characterisation to map migration of underground contamination due to:
  - Operational incidents resulting in risks of contamination spread.
  - Controlled releases into the environment during operation.
- Use of hydrogeological data recorded during site selection in view of plant construction.

02.0500 Removal of system fluids, operational waste and redundant material

02.0501 Removal of combustible material

- Increasing the nuclear safety of the shutdown installation by reducing fire hazards and the fire load in the individual rooms, removing superfluous combustible material such as:
  - Solvents.
  - Hydraulic fluids.
  - Cables.
  - Electrical cabinets, etc.

02.0502 Removal of system fluids (water, oils, etc.)

- Removal of process fluids (liquors, oils etc.):
  - Removal of process liquids from systems.
  - Transfer of process liquids to a liquid effluent processing station on or off-site.
  - Not including waste treatment activities.

02.0503 Removal of special system fluids

- Removal of special system fluids (e.g. sodium, heavy water).

02.0504 Removal of waste from decontamination

- Removal of radioactive waste produced during system decontamination for dose reduction:
  - Removal of radioactive waste produced during decontamination activities.
  - Transfer of radioactive waste to a specific processing station, on or off-site.
  - Not including waste-treatment activities.

02.0505 Removal of spent resins

- Evacuation of spent resin tanks.
- Evacuation of resin from purification stations.
- Isolation of purification stations pending subsequent decommissioning:
  - Not including waste-treatment activities.

02.0506 Removal of specific operational waste from fuel cycle facilities

- Removal of special process liquids to a specific processing station, on or off-site (not including processing of liquids and waste, which is treated under Principal Activity 05).
- Removal of HLW from decontamination.

02.0507 Removal of other waste from facility operations

- Removal of other operating waste from the facility:
  - Not including waste-treatment activities.

02.0508 Removal of redundant equipment and materials

- Removal and/or transfer of equipment and surplus spare parts which became redundant during transition period.

03 ADDITIONAL ACTIVITIES FOR SAFE ENCLOSURE OR ENTOMBMENT

Principal Activity 03 comprises all activities relating to the preparations for safe enclosure or entombment. The section is divided into three Activity Groups:

- Preparation for safe enclosure.
- Site boundary reconfiguration, isolating and securing structures.
- Facility entombment.

03.0100 Preparation for safe enclosure

03.0101 Decontamination of selected components and areas to facilitate safe enclosure

- Decontamination of areas and equipment in all buildings to be placed in dormancy, particularly those that will require periodic servicing, maintenance and/or surveillance, such as:
  - Release points.
  - Heating, ventilation, air conditioning fan/filter rooms.
  - Sampling points.
  - Waste storage areas.
  - Areas of historically high airborne radionuclide concentrations.
  - Areas where groundwater infiltration has been recorded.
- Decontamination and release of minor areas and peripheral structures which:
  - Would require excessive maintenance and/or monitoring during a dormancy period.
  - Are restricted in accessibility over the duration of the dormancy period.
- Decontamination work in rooms, areas and at equipment in order to release (in general auxiliary) buildings not to be used in subsequent decommissioning operations.
- Reorganisation, cleaning and decontamination operations in rooms, areas and of equipment in all buildings in order to reduce controlled area.
- Decontamination may include:
  - Chemical treatment.
  - High-pressure rinsing.
  - Hot-spot removal and or shielding.
  - System modifications, etc.

03.0102 Zoning for long-term storage

- Layout of dormancy period control area.
- Minimisation of controlled area requiring service and maintenance.
- Decommissioning of areas and facilities exterior to the optimised zone.

- Redesignation, relocation or re-engineering for minimum configuration, including:
  - Redefinition of the secured area.
  - Modification or reconstruction of security.
  - Surveillance and monitoring equipment.
  - Consolidation of the site facility.
- De-energising and isolation of non-essential systems
- Replacement of equipment and systems used during operations, with more efficient or less complex services, such as:
  - Ventilation.
  - Lighting.
  - Access control, etc.

03.0103 Removal of inventory not suitable for safe enclosure

- Removal/disposition of inventory:
  - Whose construction, design integrity or present condition render it unsuitable for long-term storage.
  - Where delay in the disposition would increase concerns of worker safety, complicate removal and/or significantly increase the cost of disposal.
- Removal of hazardous and toxic materials whose containment and/or encapsulation could degrade or fail over time, increasing health and safety risks and subsequent cleanup costs.
- Removal of peripheral inventory:
  - Not easily relocated to the storage boundary/controlled environment.
  - For which immediate disposition is preferred due to convenience or concern regarding future remediation criteria.

03.0104 Dismantling and transfer of contaminated equipment and material to containment structure for long-term storage

- Relocation of equipment and material suitable for long-term storage, including the preparation and/or packaging of such material for environmental isolation.
- Selective structural dismantling in support of component extraction and/or component disassembly.
- Segmentation of activated metal components.
- Removal of concrete.
- Segmentation of contaminated piping, tanks and components.
- Modifications to containment to accommodate packages including:
  - Structural enhancements for increased floor loadings.
  - Accessibility enhancements for future extraction.

03.0105 Radiological inventory characterisation for safe enclosure

- Radiological surveys in the installations.
- Non-destructive and destructive sampling for radiological characterisation of equipment and surfaces in the facilities.
- In-situ measurements of samples.

03.0200 Site boundary reconfiguration, isolating and securing structures

03.0201 Modification of auxiliary systems

- Reorganisation of support services and essential facilities for safe enclosure, including:
  - Electrical equipment.
  - Ventilation systems.
  - Fire protection equipment.

  - Lifting devices.
- Modifications in order to include process and electrical systems for:
  - Remote operation and monitoring (alarms).
  - Fire detection.
  - Reduced maintenance.

03.0202 Site boundary reconfiguration

- Physical reconfiguration of boundary to meet security requirements for safe enclosure.
- Modification/reconfiguration of existing access ways (personnel and equipment), to include security (physical and electronic barriers).
- Construction of a re-configured conventional security fence with access points for personnel and vehicles to facilitate facility operations and work co-ordination.
- Security to include:
  - Barrier construction.
  - Intrusion prevention.
  - Enhanced use of sensors.

03.0203 Construction of temporary enclosures, stores, structural enhancements, etc.,

- Construction of temporary enclosures, stores, structural enhancements, etc.:
  - To support site remediation.
  - To facilitate facility operations and work co-ordination.
- Reuse of existing buildings whether or not after prior decontamination.

03.0204 Stabilisation of radioactive and hazardous waste pending remediation

- Design, construction, operation, surveillance and later dismantling of facilities and equipment required for the removal, isolation and stabilisation of radioactive and hazardous waste, the destination of which is not covered by the preceding items.
- Reuse of existing buildings whether or not after prior decontamination.

03.0205 Facility controlled area hardening, isolation for safe enclosure

- Blocking and securing of all entrances to the controlled area, which are no longer needed.
- Protection of remaining entrances against trespassing.
- Mothballing of plant and equipment, isolation of controlled area and/or site.

03.0300 Facility entombment

03.0301 Facility entombment as end state of decommissioning strategy

- Preparation and sealing the facility for entombment.
- Entombment of remaining facility, e.g. filling with concrete.

03.0302 Institutional control and monitoring of the entombment end state

- Transfer of responsibility for institutional control.
- Periodical monitoring of entombed facility and surroundings during a specific period of time.

04 DISMANTLING ACTIVITIES WITHIN THE CONTROLLED AREA

Principal Activity 04 comprises all activities relating to the different decontamination and dismantling operations in the controlled area. Depending on the selected option, dismantling activities and related cost items in preparation of a dormancy period or in the

context of other "standard" or specific decommissioning stages can be applicable. The section is divided into nine Activity Groups:

- Procurement of equipment for decontamination and dismantling.
- Preparations and support for dismantling.
- Pre-dismantling decontamination.
- Removal of materials requiring specific procedures.
- Dismantling of main process systems, structures and components.
- Dismantling of other systems and components.
- Removal of contamination from building structures.
- Removal of contamination from areas outside buildings.
- Final radioactivity survey for release of buildings.

04.0100 Procurement of equipment for decontamination and dismantling

Activity Group 04.0100 is concerned with activities for procurement and hiring of equipment and tooling for decontamination and dismantling, design and construction of specific equipment and tooling, adaptation of equipment and tooling available off the shelf, installation, testing and licensing of this equipment and tooling. Operation activities are not included here.

Purchase or hiring of other special-purpose or other specific equipment is included in the respective cost items.

04.0101 Procurement for general site-dismantling equipment

- This includes purchase or hiring, installation, testing, licensing (operational activities to be included in decommissioning activities, however), essentially comprising lifting gear, such as:
  - Overhead cranes.
  - Jib cranes.
  - Forklift trucks.
  - Trucks, etc.
- Special lifting gear, used in isolated operations, including installation, testing, licensing (NB: operational activities should be included in decommissioning activities).

04.0102 Procurement of equipment for decontamination of personnel and tools

- Purchase, maintenance and subsequent dismantling of additional equipment for personnel and/or tooling decontamination, including installation, testing, licensing (operational activities to be included in decommissioning activities, however).

04.0103 Procurement of special tools for dismantling the reactor systems

- Procurement/adaptation of tooling for remote disassembly/segmentation of complex geometric subcomponents for a range of materials and material thickness.
- Procurement/adaptation of:
  - Highly automated articulated manipulators and other positioning devices.
  - Handling equipment for remote segmentation.
- Procurement/adaptation of:
  - Remote-viewing systems for underwater operations.
  - Feedback and control systems for underwater operations.
  - Turntables for underwater operations.
  - Support systems for maintaining water clarity.
  - Support systems for collecting cutting fines.

  - Support systems for controlling or eliminating the formation of explosive mixtures of gases generated in the cutting or from the dissolution of water.

04.0104 Procurement of special tools for dismantling in fuel cycle facilities

- Procurement/adaptation of tooling for remote disassembly/segmentation of complex geometric subcomponents for a range of materials and material thickness.
- Procurement/adaptation of:
  - Highly automated articulated manipulators and other positioning devices.
  - Handling equipment for remote segmentation.
- Procurement/adaptation of:
  - Remote-viewing systems for underwater operations.
  - Feedback and control systems for underwater operations.
  - Turntables for underwater operations.
  - Support systems for maintaining water clarity.
  - Support systems for collecting cutting fines.
  - Support systems for controlling or eliminating the formation of explosive mixtures of gases generated in the cutting or from the dissolution of water.

04.0105 Procurement of special tools for dismantling other components or structures

- Design of special tooling, adaptation, modification and/or enhancement of existing tooling for dismantling, when manual disassembly is not practical or in instances where commercially available tooling is not suitable, reliable or practical for the application.
- Procurement of the specialty tooling or field modification of commercially available hardware, where labour can be a considerable cost component.
- Leasing of specialty tooling or having the tooling made available from a subcontracted service through which operational expertise is also acquired, including concrete coring, sawing or other cutting devices, demolition hammers, etc., which, if purchased, would be cost-prohibitive for smaller applications.

04.0200 Preparations and support for dismantling

04.0201 Reconfiguration of existing services, facilities and site to support dismantling

- Reorganisation of support services and essential facilities:
  - Electrical equipment.
  - Ventilation systems.
  - Fire protection equipment.
  - Lifting devices.
- Modifications to include process and electrical systems for:
  - Remote operation and monitoring (alarms).
  - Fire detection.
  - Reduced maintenance.

04.0202 Preparation of infrastructure and logistics for dismantling

- Construction of temporary enclosures, stores, structural enhancements, etc.:
  - To support site remediation.
  - To facilitate facility operations and work co-ordination.
- Reuse of existing buildings whether or not after prior decontamination.

04.0203 Ongoing radiological characterisation during dismantling

- Characterisation for removal as needed for exposure control (ALARA), consideration in the sequence for:

  - Removal.
  - Temporary shielding.
  - Tooling selection.
  - Decontamination, etc.
- Initial characterisation for subsequent treatment of materials, considering:
  - Container selection.
  - Radionuclide and volumetric packaging limitations.
- Characterisation of materials for transportation, considering:
  - Accident/safety analyses (dispersion, exposure).
  - Shielding.
  - Documentation.
  - Notification.

04.0300 Pre-dismantling decontamination

04.0301 Drainage of remaining systems

- Drainage of systems.
- Removal of residuals from the systems.
- Removal of contaminated fluids, e.g. the spent fuel pool where the fuel with damaged cladding was stored.

04.0302 Removal of sludge and products from remaining systems

- Removal of sludge and products (residuals).
- Special designed procedures and tools, including remote operations, may be required.

04.0303 Decontamination of remaining systems

- Aggressive decontamination may be utilised.

04.0304 Decontamination of areas in buildings

- Decontamination of areas and equipment in all buildings in view of dismantling.

04.0400 Removal of materials requiring specific procedures

04.0401 Removal of thermal insulation

- Establishment of containment, ventilation, monitoring equipment.
- Use of remote handling equipment may be necessary.

04.0402 Removal of asbestos

- Establishment of containment, whether by:
  - Temporary barriers.
  - Tenting.
  - Glove bags.
- Provisions for:
  - Changing.
  - Waste handling.
  - Personnel showers, etc.
- Procurement of materials such as:
  - Fixatives.
  - Bagging.
  - Protective clothing.
  - Filters (area and respiratory).

04.0403 Removal of other hazardous materials

- Mercury, lead, PCBs, strip lighting, etc.

04.0500 Dismantling of main process systems, structures and components

04.0501 Dismantling of reactor internals

- Preparation of the work area for dismantling, extracting and packaging the waste for disposal.
- Construction of dams on vessel nozzles or gates to isolate and contain the pool being used for disassembly (if performed underwater).
- Installation of handling devices and protection systems.
- Control-rod blades and motors, rod guide tubes, RSA-guide tubes.
- Steam dryer.
- Feedwater sparger ring.
- Core shroud, including fixing.
- Fuel channels in channel type reactors.
- Monitoring of the disassembly.
- Operation of the segmentation tooling.
- Maintenance and change-out of support equipment (purification and ventilation filters).
- Accepting and preparation of the disposal containers as well as loading and processing containers for transport.
- Removal of handling devices and protection systems.

04.0502 Dismantling of reactor vessel and core components

- One-piece-removal of reactor.
- Reactor pressure vessel top head.
- Reactor core top head.
- Reactor pressure vessel including support skirt and insulation.
- Graphite structure.
- Monitoring of the disassembly.
- Operation of the segmentation tooling.
- Maintenance and change-out of support equipment (purification and ventilation filters).
- Receiving and preparing the disposal containers as well as loading and processing containers for transport.
- Removal of handling devices and protection systems.

04.0503 Dismantling of other primary loop components

- Steam generators, pressuriser.
- Primary pumps, valves and piping.
- Turbine and condenser in boiling water reactors.
- Moderator tank and loops.

04.0504 Dismantling of main process systems in fuel cycle facilities

- Process systems in mechanical hot cells.
- Process systems in chemical hot cells.
- Pools, pits, gutters.

04.0505 Dismantling of main process systems in other nuclear facilities

- Laboratories.
- Accelerators.
- Medical facilities, etc.
- Hot cells.

04.0506 Dismantling of external thermal/biological shields

- Dismantling of the activated portion of the biological/thermal or sacrificial shield which may include only that portion of the structure with

radionuclide levels in excess of the release criteria or the entire structure where partial dismantling is not an option.
- Use of any special tooling, shielded work platforms and manual or remotely operated equipment.

04.0600 Dismantling of other systems and components

04.0601 Dismantling of auxiliary systems

- Fuel handling equipment and associated components in pool, channels, hot cells, etc., including:
  - Hoists.
  - Bridges.
  - Tooling.
  - Transfer containers.
  - Storage racks.
  - Conveyors.
  - Upenders.
  - Carriages.
  - Inspection devices.
  - Cameras.
  - Manipulators.
  - Saws, etc.
- Dismantling of systems outside of the main process building.
- Laundry, workshops.

04.0602 Dismantling of remaining components

- Removal of contaminated materials (including structural), exceeding release levels, from:
  - Containment structure.
  - All other facilities.
- Removal of contaminated components that can only be dismantled at the end of the removal process, when all other components have already been removed, including:
  - Cables.
  - Lifting devices.
  - Liquid waste treatment systems.
  - Installations in the conditioning and decontamination areas.
  - Ventilation systems.
  - Gas cleaning systems.
- Removal of non-contaminated ancillary equipment in support of the final release survey, such that the removal of contamination can be demonstrated, including:
  - Any equipment, such as vessels, heat exchangers, pumps, pipes, fittings, others.
  - Structural appurtenances.
  - Liners.
  - Ductwork.
  - Penetrations.
  - Embedded components.
  - Subsurface structures, etc.

04.0700 Removal of contamination from building structures

04.0701 Removal of embedded elements in buildings

- Establishment of containment, whether by temporary barriers or by tenting.
- Removal of concrete structures around the embedded piping.
- Removal of embedded piping.

04.0702 Removal of contaminated structures

- Removal of contamination in excess of release criteria from all structures on site by the appropriate processes and technology.
- Dismantling of non-contaminated structures, fixtures, and other material for access.

04.0703 Decontamination of buildings

- Removal of contamination in excess of release criteria from all buildings on site by appropriate processes and technology.

04.0800 Removal of contamination from areas outside buildings

04.0801 Removal of underground contaminated pipes and structures

- Creating access to the underground structures.
- Establishment of containment, whether by temporary barriers or by tenting.
- Removal of concrete structures.
- Removal of piping.

04.0802 Removal of contaminated soil and other contaminated items

- Removal of surface structures to pursue subsurface contamination which have migrated to inaccessible locations over the operating life of the facility.
- Dismantling of structures, e.g. foundations and excavations beneath buildings.
- Redesign, modification or replacement of existing structures to allow floor, column and footing removal.
- Prevention of spreading of contamination, including:
  - Erosion control/stabilising.
  - Cofferdams.
  - Site dewatering.
  - Groundwater collection and treatment.
  - Monitoring wells, etc.
- Environmental clean-up, including:
  - Removal of contaminated soil.
  - Removal of contaminated sludge.
  - Removal of on-site burial facilities.

04.0900 Final radioactivity survey for release of buildings

04.0901 Final radioactivity survey of buildings

- Comprehensive survey of the facility and site following the completion of decontamination:
  - Differentiated or categorised by structures.
  - Systems and exterior areas based upon similar physical characteristics.
- Preparation of final survey, including:
  - Erection of scaffolding.
  - Identification of systems status (i.e. tag out).
  - Component disassembly, etc.
- Final survey including:
  - Specific personnel training.
  - Equipment, instrumentation calibration and testing.
  - Survey documentation.
  - Verification (quality control).
  - Independent sample analysis.
  - Confirmatory surveys, etc.
- Administrative and/or physical controls to isolate the surveyed areas, preventing recontamination once the survey has been completed.

04.0902 Declassification of buildings

- Preparing documentation for the release of buildings.
- Independent verification.

05 WASTE PROCESSING, STORAGE AND DISPOSAL

Principal Activity 05 comprises a large number of activities aiming at preparing the dismantled components either for final disposal as radioactive waste, or for release for restricted or unrestricted recycling or reuse:

- Waste management system.
- Management of historical/legacy high-level waste.
- Management of historical/legacy intermediate-level waste.
- Management of historical/legacy low-level waste.
- Management of historical/legacy very low-level waste.
- Management of historical/legacy exempt waste and materials.
- Management of decommissioning high-level waste.
- Management of decommissioning intermediate-level waste.
- Management of decommissioning low-level waste.
- Management of decommissioning very low-level waste.
- Management of decommissioning very short-lived waste.
- Management of decommissioning exempt waste and materials.
- Management of decommissioning waste and materials generated outside of controlled area.

Principal Activity 05 has two principal subsections – for historical/legacy waste (05.0200 to 05.0600) and for decommissioning waste (05.0700 to 05.1200). Items at the second levels in these principal subsections refer to basic types of waste as defined in the IAEA classification. Items at the third level refer to typical groups of waste management activities.

Individual waste management techniques which are listed within the typical groups of waste management activities may be the same for historical/legacy waste and for decommissioning waste. Where this involves costs for procurement of waste management techniques/equipment, to be used for both applications, the procurement cost should be introduced only once (e.g. according to the dominant use) and the costs for operation are evaluated separately for both segments.

The first item at the second level deals with establishment of the waste management system within the decommissioning project. The last item at the second level deals with the waste generated during dismantling and demolition activities outside the controlled are (Principal Activity 07).

05.0100 Waste management system

This Activity Group deals with establishment, maintenance and demobilisation and/or decommissioning of the waste management system in the frame of a decommissioning project. Operation of individual waste management techniques/utilities is addressed by items at the third level. Disposal of waste is considered in items at the third level. Specific waste management utilities/equipment which are not involved in the waste management system for a decommissioning project are considered in the context of relevant items at the third level.

For the purpose of presenting the cost for individual waste types, the ratio of individual types of waste on cost of the item 05.0100 may be defined.

05.0101 Establishing the waste management system

- Establishment of permanent waste management system operated in the frame of the decommissioning project.
- Procurement/hiring of portable systems/equipment for waste management.
- Mobilisation/set-up, start-up/testing/permits, specialised training.
- Design and construction of special systems not available on market including mobilisation/set-up, start-up/testing/permits, specialised training.
- Cost for establishment of waste management system is included here; the cost for processing of waste is included within the relevant individual processes.
- Processing of waste not covered by the established waste management systems is considered to be contracted as services in waste management facilities outside of the decommissioning project.
- Waste management system may involve general storage facilities; in this case the cost for establishment is included here.
- Disposal facilities are considered separately in individual items for disposal of each type of waste.

05.0102 Reconstruction of existing facilities for decommissioning waste management system

- Reconstruction of existing facilities originally used for processing of operational waste to match the requirements of the waste from decommissioning including start-up/testing/permits, specialised training.

05.0103 Procurement of additional equipment for management of historical/legacy waste

- Procurement/hiring/design and construction of portable or permanent equipment for management of types of historical/legacy waste that are additional as for types of decommissioning waste.
- Mobilisation/set-up, start-up/testing/permits, specialised training.

05.0104 Maintenance, surveillance and operational support for waste management system

- Maintenance, surveillance and operation of common auxiliary systems and building structures in waste management systems established and operated within the decommissioning project.

05.0105 Demobilisation/decommissioning of waste management system

- Decontamination, dismantling, demolition of waste management system established and operated within the decommissioning project, or of partial components of that system.
- Management of generated waste.

05.0200 Management of historical/legacy high-level waste

05.0201 Characterisation

Characterisation activities in retrieval, processing, storage, disposal and transport of historical/legacy high-level waste and developing the required documentation; radiological monitoring of processes is involved in the individual processes:

- Characterisation/documentation of waste before retrieval including systems/equipment where the waste is located, by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions, etc.) for:

  - Planning and safety assessment of procedures/instrumentation for waste retrieval.
  - Planning and safety assessment for waste management.
- Characterisation/documentation during individual retrieval and processing steps and characterisation/documentation of interim waste products for:
  - Proper and safe performing of individual processing steps and for documentation purposes.
  - Obtaining the data for subsequent processing steps.
  - Final conditioning.
- Characterisation/documentation of waste disposal packages to required physical/chemical form and the radionuclide content to confirm the acceptability for disposal (such as general requirements, radionuclide content, free liquid content, voids content, hazardous/toxic/pyrophoric/ explosive/biological/gaseous constituents, etc.)
- Procurement/hiring and/or design and construction of dedicated instrumentation for characterisation including cold and hot testing, licensing and specialised training.

05.0202 Retrieval and processing

Activities for retrieval, pre-treatment, treatment and conditioning of historical/legacy high-level waste; end point – waste ready for final conditioning:

- Procurement and/or design and construction of dedicated instrumentation for retrieval and for processing (when not involved within the waste management system) of high-level waste, including cold and hot testing, licensing and specialised training.
- Operation of dedicated instrumentation for retrieval and for processing of solid and/or liquid waste including remote.
- Arrangements for ensuring the safety and for facilitating the retrieval and processing such as shielding, elimination of leakages, safety measures, etc.
- Activities at the end of retrieval such as:
  - Decontamination of equipment where the waste had been stored.
  - Decontamination and demobilisation of equipment for retrieval.
  - Removal of waste from decontamination.
  - Stabilisation of equipment where the waste was stored.
- Remote controlled activities for handling of solid/liquid waste, fragmentation, sorting.
- Decontamination/demobilisation of dedicated instrumentation for processing of waste.
- Vitrification and/or any immobilisation/conditioning of solid and liquid waste.
- Procurement of waste packages and transport/shipping containers is included in 05.0207.

05.0203 Final conditioning

Activities for final conditioning of high-level waste; end point – conditioned waste ready for disposal or for long term storing:

- Procurement/hiring and/or design and construction of dedicated instrumentation for final conditioning of high-level waste, including cold and hot testing, licensing and specialised training (when not involved in general waste management system).
- Conditioning of waste into final disposal containers.
- Procurement of disposal containers is included in 05.0207.

05.0204 Storage

Storage activities for historical/legacy high-level waste; in some decommissioning projects, the long term storage may be the end point of waste management:

- Storage of waste in storage facilities established within the waste management system within the decommissioning project.
- Siting, design, construction, operation, maintenance, periodical inspection and decommissioning of dedicated storage facilities not involved in the waste management systems of the decommissioning project; storage of waste in these facilities.
- Storage of waste in storage facilities outside of the decommissioning project (contracted activities).
- Procurement of storage containers is included in 05.0207.

05.0205 Transport

Transport activities involved in retrieval, processing, storage and disposal of historical/legacy high-level waste:

- Transports during retrieval of waste.
- Transports of interim waste forms between individual processing steps.
- Transports of interim waste forms and/or disposal packages to/from storage facilities.
- Transport of final disposal packages to disposal facility.
- Activities related to transports such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.
- Arrangements for ensuring the safety of transports including the security aspects.
- Radiological monitoring/documentation of individual transports.
- Procurement/hiring of transport vehicles and/or, design and construction of dedicated instrumentation, development of procedures for transporting the solid and liquid waste, including cold and hot testing and licensing and specialised training.
- Procurement of transport containers is included in 05.0207.

05.0206 Disposal

Activities for disposal of historical/legacy high-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the scope of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.
- Procurement of disposal containers is included in 05.0207.

05.0207 Containers

Procurement of containers, waste packages and related instrumentations for historical/legacy high-level waste:

- Procurement of waste packages.
- Procurement of transport/shipping containers.
- Procurement of storage containers.
- Procurement of disposal containers.
- Procurement of temporary on-site storage racks or containers.

- Design and construction of dedicated specific containers and related instrumentation, including cold and hot testing, licensing and specialised training.

05.0300 Management of historical/legacy intermediate-level waste

05.0301 Characterisation

Characterisation activities in retrieval, processing, storage, disposal and transport of decommissioning intermediate-level waste and developing the required documentation; radiological monitoring of processes is involved in individual processes:

- Characterisation/documentation of waste before retrieval including systems/equipment where the waste is located, by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions etc.) for:
  - Planning and safety assessment of procedures/instrumentation for waste retrieval.
  - Planning and safety assessment for waste management.
- Characterisation/documentation of interim waste products by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions etc.) for:
  - Proper and safe performing of individual processing steps and for documentation purposes.
  - Obtaining the data for subsequent processing steps.
  - Intended disposition of the material (based upon acceptance limits for disposal and/or for release of materials).
- Characterisation/documentation of final waste disposal packages to required physical/chemical form and the radionuclide content to confirm acceptability for disposal (such as general requirements, radionuclide content, free liquid content, voids content, hazardous/toxic/pyrophoric/ explosive/biological/gaseous constituents, etc.).
- Procurement/hiring and/or design and construction of dedicated instrumentation for characterisation including cold and hot testing, licensing and specialised training.

05.0302 Retrieval and processing

Activities for retrieval, pre-treatment, treatment and conditioning of historical/legacy intermediate-level waste; end point - waste ready for final conditioning (for specific materials also for release):

- Procurement and/or design and construction of dedicated instrumentation for retrieval and for processing (when not involved within the waste management system) of intermediate-level waste, including cold and hot testing, licensing and specialised training.
- Operation of dedicated instrumentation for retrieval and for processing of solid and/or liquid waste including remote.
- Arrangements for ensuring the safety and for facilitating the retrieval and processing such as shielding, elimination of leakages, safety measures, etc.
- Activities at the end of retrieval such as:
  - Decontamination of equipment where the waste was stored.
  - Decontamination and demobilisation of equipment for retrieval.
  - Removal of waste from decontamination.
  - Stabilisation of equipment where the waste was stored.
- Handling of solid and liquid waste including remote.
- Fragmentation (manual or remote) and sorting of solid waste dependent upon:

  - Criteria for release of materials.
  - Waste form.
  - Economics of decontamination.
- Decontamination, for re-classification of waste, for recycling and reuse based upon:
  - Material type.
  - Contamination level.
  - Radionuclide characteristics.
  - The potential disposition of the material.
- Processing of solid and liquid waste by evaporation, chemical treatment, contaminant fixing, compaction, incineration, stabilisation, conditioning etc.) including:
  - Solid preparation and handling.
  - Liquid preparation and handling.
  - Vapour/gas preparation and handling.
  - Pads/foundation/spill control.
- Melting and other high-temperature processing (such as plasma based melting techniques) of contaminated metal and/or mixed materials.
- Procurement of waste packages and transport/shipping containers is included in 05.0307.

05.0303 Final conditioning

Activities for final conditioning of historical/legacy intermediate-level waste; end point – waste ready for disposal or for long term storage:

- Procurement and/or design and construction of dedicated instrumentation for final conditioning of intermediate-level waste, including cold and hot testing, licensing and specialised training (when not involved in general waste management system).
- Conditioning of waste into final disposal containers.
- Procurement of disposal containers is included in 05.0307.

05.0304 Storage

Storage activities for historical/legacy intermediate-level waste; in some decommissioning projects, the long term storage may be the end point of waste management:

- Storage of waste in storage facilities established within the waste management system within the decommissioning project.
- Siting, design, construction, operation, maintenance, periodical inspection and decommissioning of dedicated storage facilities not involved in the waste management systems of the decommissioning project; storage of waste in these facilities.
- Storage of waste in storage facilities outside of the decommissioning project (contracted activities).
- Procurement of storage containers is included in 05.0307.

05.0305 Transport

Transport activities involved in processing, storage and disposal of historical/legacy intermediate-level waste:

- Transport of interim waste forms between individual processing steps.
- Transport of interim waste forms and/or disposal packages to/from storage facilities.
- Transport of final disposal packages to disposal facility.

- Activities related to transport such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.
- Arrangements for ensuring the safety of transports including the security aspects.
- Monitoring/documentation of individual transports
- Procurement of transport vehicles and/or, design and construction of dedicated instrumentations, development of procedures for transporting the solid and liquid waste, including cold and hot testing and licensing and specialised training.
- Procurement of transport/shipping containers is included in 05.0307.

05.0306 Disposal

Activities for disposal of historical/legacy intermediate-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the boundary conditions of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.
- Procurement of disposal containers is included in 05.0307.

05.0307 Containers

Procurement of containers, waste packages and related instrumentations for historical/legacy intermediate-level waste:

- Procurement of waste packages.
- Procurement of storage containers.
- Procurement of disposal containers.
- Procurement of transport/shipping containers specific for intermediate-level waste.
- Procurement of miscellaneous special type shipping containers, including:
  - Shipping casks.
  - Liners.
  - Rail casks.
- Procurement of temporary on-site storage racks or containers.
- Design and construction of dedicated specific containers and related instrumentations, including cold and hot testing, licensing and specialised training.

05.0400 Management of historical/legacy low-level waste

05.0401 Characterisation

- Characterisation activities for processing, storage, disposal and transport of historical/legacy low-level waste and developing the required documentation; radiological monitoring of processes is involved in the individual processes.
- Characterisation/documentation of waste before retrieval including systems/equipment where the waste is located, by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions etc.) for:
  - Planning and safety assessment of procedures/instrumentation for waste retrieval.
  - Planning and safety assessment for waste management.
- Characterisation/documentation of interim waste products by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions, etc.) for:

  - Proper and safe performing of individual processing steps and for documentation purposes.
  - Obtaining the data for subsequent processing steps.
  - Intended disposition of the material (based upon acceptance limits for disposal and/or for release of materials).
- Characterisation/documentation of final waste disposal packages to required physical/chemical form and the radionuclide content to confirm the acceptability for disposal (such as general requirements, radionuclide content, free liquid content, void content, hazardous/toxic/pyrophoric/ explosive/biological/gaseous constituents, etc.)
- Procurement/hiring and/or design and construction of dedicated instrumentation for characterisation including cold and hot testing, licensing and specialised training.

05.0402 Retrieval and treatment

- Activities for retrieval, pre-treatment, treatment and conditioning of historical/legacy low-level waste; end point – waste ready for final conditioning or materials for release.
- Procurement and/or design and construction of dedicated instrumentation for retrieval and for processing (when not involved within the waste management system) of intermediate-level waste, including cold and hot testing, licensing and specialised training.
- Operation of dedicated instrumentation for retrieval and for processing of solid and/or liquid waste including remote.
- Arrangements for ensuring the safety and for facilitating the retrieval and processing such as shielding, elimination of leakages, safety measures, etc.
- Activities at the end of retrieval such as:
  - Decontamination of equipment where the waste was stored.
  - Decontamination and demobilisation of equipment for retrieval.
  - Removal of waste from decontamination.
  - Stabilisation of equipment where the waste was stored.
- Handling of solid and liquid waste.
- Fragmentation and sorting of solid waste dependent upon:
  - Criteria for release of materials.
  - Waste form.
  - Economics of decontamination.
- Decontamination, for re-classification of waste, for recycling and reuse based upon:
  - Material type.
  - Contamination level.
  - Radionuclide characteristics.
  - The potential disposition of the material.
- Processing of solid and liquid waste by evaporation, chemical treatment, contaminant fixing, compaction, incineration, stabilisation, conditioning, etc.) including:
  - Solids preparation and handling.
  - Liquid preparation and handling.
  - Vapour/gas preparation and handling.
  - Pads/foundation/spill control.
- Melting and other high-temperature processing (such as plasma based melting techniques) of contaminated metal and/or mixed materials.
- Procurement of waste packages and transport/shipping containers is included in 05.0407.

05.0403 Final conditioning

Activities for final conditioning of historical/legacy low-level waste; end point – waste ready for disposal or for long term storage:

- Procurement/hiring and/or design and construction of dedicated instrumentation for final conditioning of intermediate-level waste, including cold and hot testing, licensing and specialised training (when not involved in the waste management system).
- Conditioning of waste into final disposal containers.
- Procurement of disposal containers is included in 05.0407.

05.0404 Storage

Storage activities for historical/legacy low-level waste; in some decommissioning projects, the long term storage may be the end point of waste management:

- Storage of waste in storage facilities established within the waste management system within the decommissioning project.
- Siting, design, construction, operation, maintenance, periodical inspection and decommissioning of dedicated storage facilities not involved in the waste management systems of the decommissioning project; storage of waste in these facilities.
- Storage of waste in storage facilities outside of the decommissioning project as contracted activities.
- Procurement of storage containers is included in 05.0407.

05.0405 Transport

Transport activities involved in processing, storage and disposal of historical/legacy low-level waste:

- Transport of interim waste forms between individual processing steps.
- Transport of interim waste forms and/or disposal packages to/from storage facilities.
- Transport of final disposal packages to disposal facility.
- Activities related to transports such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.
- Arrangements for ensuring the safety of transports including the security aspects.
- Monitoring/documentation of individual transports.
- Procurement of transport vehicles and/or, design and construction of dedicated instrumentations, development of procedures for transporting the solid and liquid waste, including cold and hot testing and licensing and specialised training.
- Procurement of transport/shipping containers is included in 05.0407.

05.0406 Disposal

Activities for disposal of historical/legacy low-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the boundary conditions of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.
- Procurement of disposal containers is included in 05.0407.

05.0407 Containers

Procurement of containers, waste packages and related instrumentations for historical/legacy low-level waste:

- Procurement of waste packages.
- Procurement of storage containers.
- Procurement of disposal containers.
- Procurement of transport/shipping containers specific for low-level waste.
- Procurement of miscellaneous special type shipping containers, including:
  - Shipping casks.
  - Liners.
  - Rail casks.
- Procurement of low specific activity shipping containers, including:
  - Strong tight containers.
  - Liners.
  - Drums and pails.
  - Shipping casks.
- Procurement of temporary on-site storage racks or containers;
- Design and construction of dedicated specific containers and related instrumentations, including cold and hot testing, licensing and specialised training.

05.0500 Management of historical/legacy very low-level waste

05.0501 Characterisation

Characterisation activities for treatment, packaging, disposal and transport of historical/legacy very low-level waste and developing the required documentation:

- Characterisation/documentation of waste before retrieval including systems/equipment where the waste is located, by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions etc.) for:
  - Planning and safety assessment of procedures/instrumentation for waste retrieval.
  - Planning and safety assessment for waste management.
- Characterisation/documentation of waste entering the processing and interim waste products, mostly by direct surveys and sampling for:
  - Documenting the processes.
  - Intended disposition of the material (based upon acceptance limits for disposal and/or for release of materials).
- Characterisation/documentation of final waste disposal packages to required physical and chemical form, radionuclide content and other requirements to confirm the acceptability for disposal.

05.0502 Retrieval, treatment and packaging

Activities for retrieval, pre-treatment, treatment and conditioning of decommissioning very low-level waste:

- Procurement and/or design and construction of dedicated instrumentation for retrieval of waste, including cold and hot testing and licensing and specialised training.
- Operation of instrumentation for retrieval of solid and/or liquid waste.
- Arrangements for ensuring the safety and for facilitating the retrieval such as elimination of leakages, safety measures, etc.
- Activities at the end of retrieval such as:
  - Decontamination of equipment where the waste had been stored.

  - Decontamination and demobilisation of equipment for retrieval.
  - Removal of waste from decontamination.
  - Stabilisation of equipment where the waste was stored.
- Handling of solid and liquid waste using relatively simple techniques.
- Fragmentation and sorting of solid waste dependent based upon:
  - Criteria for release of materials.
  - Waste form.
  - Economics of decontamination.
- Decontamination for recycling and reuse.
- Processing of solid and liquid waste (using mostly simple techniques).
- Processing of contaminated soils.
- Processing of all secondary waste.
- Short term storage on site.
- Packaging of very low-level waste for disposal using simple packages such as plastic or textile bags; containers are not considered for disposal.

05.0503 Transport

Transport activities related to treatment, packaging and disposal of historical/legacy very low-level waste:

- Transports of interim waste forms between individual processing steps.
- Transport of final disposal packages to disposal facility.
- Activities related to transports such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.
- Monitoring/documentation of individual transports.
- Procurement/hiring of transport vehicles and containers and/or, design and construction of dedicated instrumentations if needed, including licensing.

05.0504 Disposal

Activities for disposal of decommissioning very low-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the boundary conditions of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.

05.0600 Management of historical/legacy exempt waste and materials

05.0601 Retrieval, treatment and packaging

Activities for retrieval, treatment and packaging of historical/legacy exempt waste and materials:

- Simple handling, treatment and monitoring of conventional exempt waste and materials.
- Handling and monitoring of hazardous exempt waste before clearance.
- Putting the exempt waste and materials into approved packages for clearance monitoring (such as drums).
- Procurement/hiring of any instrumentation (if needed).

05.0602 Clearance measurement of exempt waste and materials

Activities for free release and for conditioned release of exempt waste and materials:

- Scanning of drums with exempt waste, materials and decontaminated materials, dependent upon established criteria for free release and for future reuse of conditionally released materials.
- Developing the documentation for released materials.

- Handling with exempt waste and materials after the clearance process.
- Procurement/hiring of dedicated instrumentation for clearance measurements.
- Developing the procedures for clearance measurements.
- Maintenance, periodical calibration of instrumentation and upgrading of clearance procedures.

05.0603 Transport of hazardous waste

Transport activities related to clearance of hazardous waste:

- Transport of exempt hazardous waste to dedicated waste dumps sites.
- Activities related to transports such as handling with containers, loading, unloading, etc.
- Any safety measures relevant to type of hazardous materials.
- Procurement/hiring of transport vehicles and containers (if needed).

05.0604 Disposal of hazardous waste at dedicated waste dumps

- Disposal of hazardous waste at dedicated waste dump sites.

05.0605 Transport of conventional waste and materials

Transport activities related to clearance of conventional waste and materials:

- Transport of exempt conventional waste to conventional waste dumps sites.
- Transport of reusable materials to places for its reuse.
- Activities related to transport such as handling of containers, loading, unloading, etc.
- Procurement/hiring of transport vehicles and containers (if needed).

05.0606 Disposal of conventional waste at conventional waste dumps

- Disposal of conventional waste at public dump sites.

05.0700 Management of decommissioning high-level waste

05.0701 Characterisation

Characterisation activities in processing, storage, disposal and transport of decommissioning high-level waste and developing the required documentation; radiological monitoring of processes is involved in the individual processes:

- Characterisation/documentation of waste entering the processing by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions, etc.) for:
  - Ensuring of implementation of proper processing techniques.
  - Keeping the safety during processes.
- Characterisation/documentation of interim waste products by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions, etc.) for:
  - Proper and safe performing of individual processing steps and for documentation purposes.
  - Obtaining the data for subsequent processing steps.
  - Final conditioning.
- Characterisation/documentation of final waste disposal packages to required physical/chemical form and the radionuclide content to confirm the acceptability for disposal (such as general requirements, radionuclide content, free liquid content, voids content, hazardous/toxic/pyrophoric/ explosive/biological/gaseous constituents, etc.)
- Procurement/hiring and/or design and construction of dedicated instrumentation for characterisation including cold and hot testing, licensing and specialised training.

05.0702 Processing

Activities for pre-treatment, treatment and conditioning of decommissioning high-level waste; end point – waste ready for final conditioning:

- Procurement/hiring and/or design and construction of dedicated instrumentation for processing of waste, including cold and hot testing, licensing and specialised training (when not involved within the waste management system).
- Operation/demobilisation/decommissioning of dedicated instrumentation for processing of solid and/or liquid waste including remote.
- Arrangements for ensuring the safety and for facilitating the processing such as shielding, elimination of leakages, safety measures, etc.
- Remote controlled activities for handling of solid/liquid waste, fragmentation, sorting.
- Vitrification and/or any immobilization/conditioning of solid and liquid waste.
- Procurement of waste packages and transport/shipping containers is included in 05.0707.

05.0703 Final conditioning

Activities for final conditioning of high-level waste; end point – conditioned waste ready for disposal or for long term storing:

- Procurement/hiring and/or design and construction of dedicated instrumentation for final conditioning of high-level waste, including cold and hot testing, licensing and specialised training (when not involved in general waste management system).
- Conditioning of waste into final disposal containers.
- Procurement of disposal containers is included in 05.0707.

05.0704 Storage

Storage activities for decommissioning high-level waste; in some decommissioning projects, the long term storage may be the end point of waste management:

- Storage of waste in storage facilities established within the waste management system within the decommissioning project.
- Siting, design, construction, operation, maintenance, periodical inspection and decommissioning of dedicated storage facilities not involved in the waste management systems of the decommissioning project; storage of waste in these facilities.
- Storage of waste in storage facilities outside of the decommissioning project (contracted activities).
- Procurement of storage containers is included in 05.0707.

05.0705 Transport

Transport activities involved in processing, storage and disposal of decommissioning high-level waste:

- Transport of interim waste forms between individual processing steps.
- Transport of interim waste forms and/or disposal packages to/from storage facilities.
- Transport of final disposal packages to disposal facility.
- Activities related to transports such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.

- Arrangements for ensuring the safety of transports including the security aspects.
- Radiological monitoring/documentation of individual transports.
- Procurement/hiring of transport vehicles and/or, design and construction of dedicated instrumentations, development of procedures for transporting the solid and liquid waste, including cold and hot testing and licensing and specialised training.
- Procurement of transport containers is included in 05.0707.

05.0706 Disposal

Activities for disposal of decommissioning high-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the boundary conditions of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.
- Procurement of disposal containers is included in 05.0707.

05.0707 Containers

Procurement of containers, waste packages and related instrumentations for decommissioning high-level waste:

- Procurement of waste packages.
- Procurement of transport/shipping containers.
- Procurement of storage containers.
- Procurement of disposal containers.
- Procurement of temporary on-site storage racks or containers.
- Design and construction of dedicated specific containers and related instrumentations, including cold and hot testing, licensing and specialised training.

05.0800 Management of decommissioning intermediate-level waste

05.0801 Characterisation

Characterisation activities in processing, storage, disposal and transport of decommissioning intermediate-level waste and developing the required documentation; radiological monitoring of processes is involved in individual processes:

- Characterisation/documentation of waste entering the processing by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions, etc.) for:
  - Ensuring of implementation of proper processing techniques.
  - Keeping the safety during processes.
- Characterisation/documentation of interim waste products by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions, etc.) for:
  - Proper and safe performance of individual processing steps and for documentation purposes.
  - Obtaining the data for subsequent processing steps.
  - Intended disposition of the material (based upon acceptance limits for disposal and/or for release of materials).
- Characterisation/documentation of final waste disposal packages to required physical/chemical form and the radionuclide content to confirm the acceptability for disposal (such as general requirements, radionuclide content, free liquid content, voids content, hazardous/toxic/pyrophoric/ explosive/biological/gaseous constituents, etc.).

- Procurement/hiring and/or design and construction of dedicated instrumentation for characterisation including cold and hot testing, licensing and specialised training.

05.0802 Processing

Activities for pre-treatment, treatment and conditioning of decommissioning intermediate-level waste; end point waste ready for final conditioning (for specific materials also for release):

- Procurement/hiring and/or design and construction of dedicated instrumentation for processing of waste, including cold and hot testing and licensing and specialised training (when not involved within the waste management system).
- Operation/demobilisation/decommissioning of dedicated instrumentation for processing of solid and/or liquid waste including remote.
- Arrangements for ensuring the safety and for facilitating the processing of waste such as shielding, elimination of leakages, safety measures, etc.
- Handling of solid and liquid waste including remote.
- Fragmentation (manual or remote) and sorting of solid waste dependent upon:
  - Criteria for release of materials.
  - Waste form.
  - Economics of decontamination.
- Decontamination, for re-classification of waste, for recycling and reuse based upon:
  - Material type.
  - Contamination level.
  - Radionuclide characteristics.
  - The potential disposition of the material.
- Processing of solid and liquid waste by evaporation, chemical treatment, contaminant fixing, compaction, incineration, stabilisation, conditioning, etc.) including:
  - Solids preparation and handling.
  - Liquid preparation and handling.
  - Vapour/gas preparation and handling.
  - Pads/foundation/spill control.
- Melting and other high-temperature processing (such as plasma based melting techniques) of contaminated metal and/or mixed materials.
- Procurement of waste packages and transport/shipping containers is included in 05.0807.

05.0803 Final conditioning

Activities for final conditioning of decommissioning intermediate-level waste; end point – waste ready for disposal or for long term storage:

- Procurement and/or design and construction of dedicated instrumentation for final conditioning of intermediate-level waste, including cold and hot testing, licensing and specialised training (when not involved in general waste management system).
- Conditioning of waste into final disposal containers.
- Procurement of disposal containers is included in 05.0807.

05.0804 Storage

Storage activities for decommissioning intermediate-level waste; in some decommissioning projects, the long term storage may be the end point of waste management:

- Storage of waste in storage facilities established within the waste management system within the decommissioning project.
- Siting, design, construction, operation, maintenance, periodical inspection and decommissioning of dedicated storage facilities not involved in the waste management systems of the decommissioning project; storage of waste in these facilities.
- Storage of waste in storage facilities outside of the decommissioning project (contracted activities).
- Procurement of storage containers is included in 05.0807.

05.0805 Transport

Transport activities involved in processing, storage and disposal of decommissioning intermediate-level waste:

- Transport of interim waste forms between individual processing steps.
- Transport of interim waste forms and/or disposal packages to/from storage facilities.
- Transport of final disposal packages to disposal facility.
- Activities related to transport such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.
- Arrangements for ensuring the safety of transport including the security aspects.
- Monitoring/documentation of individual transports.
- Procurement of transport vehicles and/or, design and construction of dedicated instrumentations, development of procedures for transporting the solid and liquid waste, including cold and hot testing and licensing and specialised training.
- Procurement of transport/shipping containers is included in 05.0807.

05.0806 Disposal

Activities for disposal of decommissioning intermediate-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the boundary conditions of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.
- Procurement of disposal containers is included in 05.0807.

05.0807 Containers

Procurement of containers, waste packages and related instrumentations for decommissioning intermediate-level waste:

- Procurement of waste packages.
- Procurement of storage containers.
- Procurement of disposal containers.
- Procurement of transport/shipping containers specific for intermediate-level waste.
- Procurement of miscellaneous special type shipping containers, including:
  - Shipping casks.
  - Liners.
  - Rail casks.
- Procurement of temporary on-site storage racks or containers.
- Design and construction of dedicated specific containers and related instrumentations, including cold and hot testing, licensing and specialised training.

05.0900 Management of decommissioning low-level waste

05.0901 Characterisation

Characterisation activities for processing, storage, disposal and transport of decommissioning low-level waste and developing the required documentation; radiological monitoring of processes is involved in the individual processes:

- Characterisation/documentation of waste entering the processing by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions etc.) for:
  - Ensuring of implementation of proper processing techniques.
  - Keeping the safety during processes.
- Characterisation/documentation of interim waste products by direct surveys, sampling, destructive/chemical analysis (depending on waste form, geometry, accessibility, radiological conditions etc.) for:
  - Proper and safe performing of individual processing steps and for documentation purposes.
  - Obtaining the data for subsequent processing steps.
  - Intended disposition of the material (based upon acceptance limits for disposal and/or for release of materials).
- Characterisation/documentation of final waste disposal packages to required physical/chemical form and the radionuclide content to confirm the acceptability for disposal (such as general requirements, radionuclide content, free liquid content, voids content, hazardous/toxic/pyrophoric/ explosive/biological/gaseous constituents, etc.)
- Procurement/hiring and/or design and construction of dedicated instrumentation for characterisation including cold and hot testing, licensing and specialised training.

05.0902 Processing

Activities for pre-treatment, treatment and conditioning of decommissioning low-level waste; end point – waste ready for final conditioning or materials for release:

- Procurement/hiring and/or design and construction of dedicated instrumentation for processing and handling of waste, including cold and hot testing and licensing and specialised training; when not involved in the waste management system.
- Operation/demobilisation/decommissioning of dedicated instrumentation for processing and handling of solid and/or liquid waste.
- Arrangements for ensuring the safety and for facilitating the processing of waste such as shielding, elimination of leakages, safety measures, etc.
- Handling of solid and liquid waste.
- Fragmentation and sorting of solid waste dependent upon:
  - Criteria for release of materials.
  - Waste form.
  - Economics of decontamination.
- Decontamination, for declassification of waste, for recycling and reuse based upon:
  - Material type.
  - Contamination level.
  - Radionuclide characteristics.
  - The potential disposition of the material.
- Processing of solid and liquid waste by evaporation, chemical treatment, contaminant fixing, compaction, incineration, stabilisation, conditioning, etc. including:
  - Solids preparation and handling.

  - Liquid preparation and handling.
  - Vapour/gas preparation and handling.
  - Pads/foundation/spill control.
- Melting and other high-temperature processing (such as plasma based melting techniques) of contaminated metal and/or mixed materials.
- Processing of all secondary waste.
- Procurement of waste packages and transport/shipping containers is included in 05.0907.

05.0903 Final conditioning

Activities for final conditioning of decommissioning low-level waste; end point - waste ready for disposal or for long term storage:

- Procurement/hiring and/or design and construction of dedicated instrumentation for final conditioning of intermediate-level waste, including cold and hot testing, licensing and specialised training (when not involved in the waste management system).
- Conditioning of waste into final disposal containers.
- Procurement of disposal containers is included in 05.0907.

05.0904 Storage

Storage activities for decommissioning low-level waste; in some decommissioning projects, the long term storage may be the end point of waste management:

- Storage of waste in storage facilities established within the waste management system within the decommissioning project.
- Siting, design, construction, operation, maintenance, periodical inspection and decommissioning of dedicated storage facilities not involved in the waste management systems of the decommissioning project; storage of waste in these facilities .
- Storage of waste in storage facilities outside of the decommissioning project as contracted activities.
- Procurement of storage containers is included in 05.0707.

05.0905 Transport

Transport activities involved in processing, storage and disposal of decommissioning low-level waste:

- Transport of interim waste forms between individual processing steps.
- Transport of interim waste forms and/or disposal packages to/from storage facilities.
- Transport of final disposal packages to disposal facility.
- Activities related to transports such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.
- Arrangements for ensuring the safety of transports including the security aspects.
- Monitoring/documentation of individual transports.
- Procurement of transport vehicles and/or, design and construction of dedicated instrumentations, development of procedures for transporting the solid and liquid waste, including cold and hot testing and licensing and specialised training.
- Procurement of transport/shipping containers is included in 05.0907.

05.0906 Disposal

Activities for disposal of decommissioning low-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the boundary conditions of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.
- Procurement of disposal containers is included in 05.0907.

05.0907 Containers

Procurement of containers, waste packages and related instrumentations for decommissioning low-level waste:

- Procurement of waste packages.
- Procurement of storage containers.
- Procurement of disposal containers.
- Procurement of transport/shipping containers specific for low-level waste.
- Procurement of miscellaneous special type shipping containers, including:
  - Shipping casks.
  - Liners.
  - Rail casks.
- Procurement of low specific activity shipping containers, including:
  - Strong tight containers.
  - Liners.
  - Drums and pails.
  - Shipping casks.
- Procurement of temporary on-site storage racks or containers.
- Design and construction of dedicated specific containers and related instrumentations, including cold and hot testing, licensing and specialised training.

05.1000 Management of decommissioning very low-level waste

05.1001 Characterisation

Characterisation activities for treatment, packaging, disposal and transport of decommissioning very low-level waste and developing the required documentation:

- Characterisation/documentation of waste entering the processing and interim waste products, mostly by direct surveys and sampling for:
  - Documenting the processes.
  - Intended disposition of the material (based upon acceptance limits for disposal and/or for release of materials).
- Characterisation/documentation of final waste disposal packages to required physical and chemical form, radionuclide content and other requirements to confirm the acceptability for disposal.

05.1002 Treatment and packaging

Activities for pre-treatment, treatment and conditioning of decommissioning very low-level waste:

- Handling of solid and liquid waste using relatively simple techniques.
- Fragmentation and sorting of solid waste dependent based upon:
  - Criteria for release of materials.
  - Waste form.
  - Economics of decontamination.

- Decontamination for recycling and reuse.
- Processing of solid and liquid waste (using mostly simple techniques).
- Processing of contaminated soils.
- Processing of all secondary waste.
- Short term storage on site.
- Packaging of very low-level waste for disposal using simple packages such as plastic or textile bags; containers are not considered for disposal.

05.1003 Transport

Transport activities related to treatment, packaging and disposal of decommissioning very low-level waste:

- Transport of interim waste forms between individual processing steps.
- Transport of final disposal packages to disposal facility.
- Activities related to transports such as handling of containers, loading, unloading, pumping of liquid waste and sludge, decontamination and monitoring of containers, etc.
- Monitoring/documentation of individual transports.
- Procurement/hiring of transport vehicles and containers and/or, design and construction of dedicated instrumentations if needed, including licensing.

05.1004 Disposal

Activities for disposal of decommissioning very low-level waste:

- Siting, design, construction, operation and closure of the repository if this is within the boundary conditions of the decommissioning project; disposal of waste at this repository.
- Disposal of waste at disposal sites outside of the decommissioning project.

05.1100 Management of decommissioning very short-lived waste

05.1101 Characterisation

- Any characterisation activities involved in treatment, storage, handling and packaging of very short-lived waste and developing the required documentation.

05.1102 Treatment, storage, handling and packaging

Activities for treatment, storage, handling and packaging of very short-lived waste:

- Simple treatment activities for modification of the form of the waste (if needed).
- Temporary storage on site.
- Handling and monitoring activities.
- Packaging of very short-lived waste before clearance.

05.1103 Final management of decommissioning very short-lived waste

- Final management of very short-lived waste after clearance.

05.1200 Management of decommissioning exempt waste and materials

05.1201 Treatment and packaging

Activities for treatment and packaging of decommissioning exempt waste and materials:

- Simple handling, treatment and monitoring of conventional exempt waste and materials.
- Handling and monitoring of hazardous exempt waste before clearance.

- Putting the exempt waste and materials into approved packages for clearance monitoring (such as drums).
- Procurement/hiring of any instrumentation (if needed).

05.1202 Clearance measurement of exempt waste and materials

Activities for free release and for conditioned release of waste and materials:

- Scanning of drums with exempt waste, materials and decontaminated materials, dependent upon established criteria for free release and for future reuse of conditionally released materials.
- Developing the documentation for released materials.
- Handling with exempt waste and materials after the clearance process.
- Procurement/hiring of dedicated instrumentation for clearance measurements.
- Developing the procedures for clearance measurements.
- Maintenance, periodical calibration of instrumentation and upgrading of clearance procedures.

05.1203 Transport of hazardous waste

Transport activities related to clearance of hazardous waste:

- Transport of exempt hazardous waste to dedicated waste dumps sites.
- Activities related to transports such as handling with containers, loading, unloading, etc.
- Any safety measures relevant to type of hazardous materials.
- Procurement/hiring of transport vehicles and containers (if needed).

05.1204 Disposal of hazardous waste at dedicated waste dumps

- Disposal of hazardous waste at dedicated waste dump sites.

05.1205 Transport of conventional waste and materials

Transport activities related to clearance of conventional waste and materials:

- Transport of exempt conventional waste to conventional waste disposal sites.
- Transport of reusable materials to places for its reuse.
- Activities related to transports such as handling with containers, loading, unloading, etc.
- Procurement/hiring of transport vehicles and containers (if needed).

05.1206 Disposal of conventional waste at conventional waste dumps

- Disposal of conventional waste at public dump sites.

05.1300 Management of decommissioning waste and materials generated outside controlled areas

05.1301 Recycling of concrete

Activities related to on-site or off-site recycling of concrete and other building materials:

- Preparation and decommissioning of temporary storage yard for materials from demolition and for recycled materials.
- Procurement/hiring, installation and demobilisation of the recycling machine(s).
- Recycling of concrete and other building materials.
- Separation of the steel reinforcement bars.
- Handling with recycled materials.

05.1302 Treatment and packaging of hazardous waste

Activities related to treatment and packaging of hazardous waste:

- Establishment, operation, demobilisation/decommissioning of temporary facilities for treatment and packaging of hazardous waste.
- Sorting, treatment, fixation of hazardous waste and other activities.
- Packaging of hazardous waste.
- Any safety measures relevant to type of hazardous materials.

05.1303 Treatment and recycling of other materials

Activities related to recycling of other materials from dismantling and demolition outside of the controlled area:

- Establishment, operation, demobilisation/decommissioning of temporary facilities for recycling of other materials.
- Segmentation of large equipment.
- Fragmentation and sorting of reusable materials (steels, colour metals, etc).
- Handling of sorted materials and useless waste.
- Separation and transport of hazardous waste to treatment places for hazardous waste.

05.1304 Transport of hazardous waste

Activities related to transport of hazardous waste:

- Transport of hazardous waste at dedicated waste disposal sites.
- Activities related to transports such as handling with containers, loading, unloading, etc.
- Any safety measures relevant to type of hazardous materials.
- Procurement/hiring of transport vehicles and containers (if needed).

05.1305 Disposal of hazardous waste at dedicated waste dumps

- Disposal of hazardous waste at dedicated waste dump sites.

05.1306 Transport of conventional waste and materials

Activities related to transport of conventional waste and reusable materials.

- Transport of conventional waste to public waste disposal sites.
- Transport of reusable materials to places for its reuse.
- Activities related to transports such as handling with containers, loading, unloading, etc.
- Procurement/hiring of transport vehicles and containers (if needed).

05.1307 Disposal of conventional waste at conventional waste dumps

- Disposal of conventional waste at public dump sites.

06 SITE INFRASTRUCTURE AND OPERATION

Principal Activity 06 is divided into four Activity Groups, mainly addressing site protection, control and maintenance activities:

- Site security and surveillance.
- Site operation and maintenance.
- Operation of support systems.
- Radiation and environmental safety monitoring.

Some of the sub-activities of Principal Activity 06 may be contracted. Some contracted security, surveillance and monitoring activities may be performed remotely.

06.0100 Site security and surveillance

06.0101 Procurement of general security equipment

- Equipment required for the surveillance of facilities either pending decommissioning or being partially dismantled, in view of minimising personnel costs during long-term storage, including installation, testing, licensing (operational activities to be included in decommissioning activities, however).
- Security fences (new), including installation, testing, licensing (operational activities to be included in decommissioning activities, however).

06.0102 Operation and maintenance of automated access control systems, monitoring systems and alarms

- Modification of automated access control systems and monitoring systems and alarms from the operational period according to the requirements of the decommissioning project.
- Operation and maintenance of automated access control systems and monitoring systems and alarms.
- Modifications of automated access control systems and monitoring systems and alarms according to requirements of individual phases of the decommissioning project.

06.0103 Security fencing and protection of remaining entrances against trespassing

- Modification of security fencing and entrances from the operational period according to the requirements of the decommissioning project.
- Protection of remaining not used entrances against trespassing.
- Operation and maintenance of the security fencing.
- Modifications of security fencing and entrances according to the requirements of individual phases of the decommissioning project.

06.0104 Deployment of guards/security forces

- Personnel for guards and security according to the requirements of individual phases of the decommissioning project.

06.0200 Site operation and maintenance

06.0201 Inspection and maintenance of buildings and systems

- Monitoring of systems and structures necessary to support dormancy and/or decommissioning, excluding security systems.
- Maintenance/replacement of systems and structures necessary to support dormancy and/or decommissioning, excluding security systems.
- Disabling, modifications and caretaking of redundant equipment.
- Regulatory assessment/compliance and inspections.

06.0202 Site upkeep activities

- Grounds keeping.
- Mowing grass.
- Raking leaves, miscellaneous trash.
- Road and parking lot maintenance.
- Storm drain maintenance.

06.0300 Operation of support systems

Some of the support systems are used for distribution of electricity, water, steam, technical gases and other consumables to individual decommissioning activities. The cost of these consumables may be allocated to individual decommissioning activities or to the operation of individual support systems. The mode of allocation of these costs shall be presented.

06.0301 Electricity supply systems

- Modifications of the systems according to the requirements of individual phases of the decommissioning project and shutdown of the system at the end of operation.
- Operation and maintenance of the systems; the extent of personnel and activities depends on requirements of individual phases of the decommissioning project.

06.0302 Ventilation systems

- Modifications of the systems according to the requirements of individual phases of the decommissioning project and shutdown of the system at the end of operation.
- Operation and maintenance of the systems; the extent of personnel and activities depends on requirements of individual phases of the decommissioning project.

06.0303 Heating, steam and lighting systems

- Modifications of the systems according to the requirements of individual phases of the decommissioning project and shutdown of the system at the end of operation.
- Operation and maintenance of the systems; the extent of personnel and activities depends on requirements of individual phases of the decommissioning project.

06.0304 Water supply systems

- Modifications of the systems according to the requirements of individual phases of the decommissioning project and shutdown of the system at the end of operation.
- Operation and maintenance of the systems; the extent of personnel and activities depends on requirements of individual phases of the decommissioning project.

06.0305 Sewage/waste water systems

- Modifications of the systems according to the requirements of individual phases of the decommissioning project and shutdown of the system at the end of operation.
- Operation and maintenance of the systems; the extent of personnel and activities depends on requirements of individual phases of the decommissioning project.

06.0306 Compressed air/nitrogen systems

- Modifications of the systems according to the requirements of individual phases of the decommissioning project and shutdown of the system at the end of operation.
- Operation and maintenance of the systems; the extent of personnel and activities depends on requirements of individual phases of the decommissioning project.

06.0307 Other systems

- Modifications of systems according to the requirements of individual phases of the decommissioning project and shutdown of the system at the end of operation.
- Operation and maintenance of systems; the extent of personnel and activities depends on requirements of individual phases of the decommissioning project.

06.0400 Radiation and environmental safety monitoring

06.0401 Procurement and maintenance of equipment for radiation protection and environmental monitoring

- General radiation protection equipment such as portal monitoring systems at controlled area exits, including installation, testing, licensing (operational activities to be included in decommissioning activities, however).
- Portable monitoring equipment for dose rate measurements and/or contamination measurements, including installation, testing, licensing (operational activities to be included in decommissioning activities, however).
- Monitoring equipment for decommissioning operations measurements, including installation, testing, licensing (operational activities to be included in decommissioning activities, however).
- Environmental monitoring equipment, including installation, testing, licensing (operational activities to be included in decommissioning activities).

06.0402 Radiation protection and monitoring

- Supporting field operations and maintain organisational control of the facility.
- Radiation protection technologist, dosimetry specialist.
- Setting work area/access requirements.
- Maintaining documentation of the facility's changing radiological conditions.
- Providing dosimetry and personnel protection, etc.
- Area monitoring, including:
  - Alarm systems.
  - Geiger-Muller/scintillation survey metering.
  - Ion chamber survey metering.
  - Tritium monitoring.
  - Special case monitoring.
- Personal dosimetry, including:
  - Audible alarm systems.
  - Film badging.
  - Pocket ion chambers.
- Personnel radiation counting, including:
  - Doorway monitoring.
  - Hand and foot monitoring.
  - Whole body monitoring.
  - Handheld monitoring.
- Dosimetry systems, including:
  - Electronic dosimeters/readers/accessories.
  - Thermoluminescence dosimeters/readers/components.
- Diagnostics, quality assurance and calibration, including:
  - Off-site calibration.
  - On-site calibration.
  - Calibration standards.

- Operational activities, including:
  - Surveying.
  - Radiation protection training.
  - Work area monitoring.
  - Personal protective equipment surveying.
  - Radioactive contamination protective equipment surveying.
  - Personnel decontamination.

06.0403 Environmental protection and radiation environmental monitoring

- Monitoring and recording airborne radiation levels inside and outside of structures.
- Monitoring and recording water contamination levels in facility systems and storm drainage systems.
- Soil sampling, analysis, and recording of results.

07 CONVENTIONAL DISMANTLING, DEMOLITION AND SITE RESTORATION

In general, Principal Activity 07 considers the non-radiological portions of plant decommissioning. It involves six Activity Groups:

- Procurement of equipment for conventional dismantling and demolition.
- Dismantling of systems and building components outside of the controlled area.
- Demolition of buildings and structures.
- Final cleanup, landscaping and refurbishment.
- Final radioactivity survey of site.
- Perpetuity funding/surveillance for limited or restricted release of property.

07.0100 Procurement of equipment for conventional dismantling and demolition

07.0101 Procurement of equipment for conventional dismantling and demolition

- Includes purchase or hiring, installation, testing, maintenance of equipment used in conventional dismantling and demolition (NB: operational activities are included in decommissioning activities) such as:
  - Jib cranes.
  - Forklift trucks.
  - Trucks, etc.
  - Pneumatic drills and hammers.
  - Demolition robots.
- Special lifting gear, used in isolated operations, including installation, testing, licensing and maintenance (operational activities to be included in decommissioning activities, however).

07.0200 Dismantling of systems and building components outside the controlled area

Dismantling of non-usable, clean balance-of-plant systems, including:

07.0201 Electricity generating system

- Turbine generator.
- Electrical motor control centres (MCC).
- Cable trays and conduits.

07.0202 Cooling system components

- Component cooling systems.
- Make-up water systems.
- Feedwater systems.

- Condenser cooling systems.
- Condensate systems.

07.0203 Other auxiliary systems

- Sampling systems.
- Instrumentation systems.
- Compressed air systems.
- Instrument air systems.
- Security systems.
- Fire protection systems.
- Air conditioning and heating.
- Other or equivalent systems.

07.0300 Demolition of buildings and structures

07.0301 Demolition of buildings and structures from the formerly controlled area

- Complete demolition of partially demolished buildings or structures:
  - Damaged during the radiological removal stage.
  - Deemed to be unstable because of age, structural condition or obsolescence.
- Demolition to the defined level (e.g. to the level of -1 m) or complete demolition (including the foundations and base plates) of the decontaminated remaining portions of buildings such as:
  - Reactor buildings.
  - Main processing buildings in non-reactor facilities.
  - Auxiliary buildings.
  - Used fuel storage buildings.
  - Low-level waste storage buildings.
  - Radioactive waste treatment buildings.
- Modification of remaining underground structures below the defined level (e.g. below the level of -1 m) to facilitate backfilling (e.g. by partial destruction of ceilings).
- Backfilling the underground voids to the defined level (e.g. to the level of -1 m).

07.0302 Demolition of buildings and structures outside the controlled area

- Complete demolition of partially demolished buildings or structures:
  - Deemed to be unstable because of age, structural condition or obsolescence.
- Dismantling and demolition to the defined level (e.g. to the level of -1 m) or complete demolition (including the foundations and base plates) of the remaining portions of the clean buildings and structures as the:
  - Storage building for fresh fuel.
  - Cooling towers.
  - Cooling water intake and outlet structures.
  - Turbine generator hall.
  - Diesel generator building.
  - Warehouses and shops.
  - Railbeds.
  - Roadbeds.
  - Meteorological towers.
  - Security fencing.
  - Security building.
  - Other or equivalent systems.

- Modification of remaining underground structures below the defined level (e.g. below the level of -1 m) to facilitate backfilling (e.g. by partial destruction of ceilings).
- Backfilling the underground voids to the defined level (e.g. to the level of 1 m) using for example the on–site recycled building materials.

07.0303 Dismantling of the stack

- Dismantling and demolition of the decontaminated remaining portions of the stack.
- Lifting out of foundations.

07.0400 Final cleanup, landscaping and refurbishment

07.0401 Earthworks, landworks

- Earthwork, including:
  - Rock excavation.
  - Excavation/fill.
  - Backfill.
  - Site bulldozing and grading.
- Adding clean fill where needed to conform site topography to adjacent landscape, including:
  - Borrowing.
  - Hauling.
  - Spreading.
  - Grading.
  - Compaction.
- Landworks, including:
  - Scarification.
  - Harrowing.
  - Tracking.
  - Contour furrowing.

07.0402 Landscaping and other site finishing activities

- Landscaping, including:
  - Stockpiling.
  - Adding topsoil or loam to support re-vegetation of the site and stabilisation of the soil.
  - Settlement markers.
- Planting, including:
  - Seeding/mulch/fertiliser.
  - Erosion control fabric.
  - Shrubs.
  - Trees ground cover.
- Permanent markers.
- Re-establish roads/structures/utilities.
- Removal of barriers.

07.0403 Refurbishment of buildings

- Refurbishment of that portion of salvageable buildings or structures that can be made usable by reasonable restoration; refurbished buildings may be a subject of asset recovery (Chapter 11.0400).

07.0500 Final radioactivity survey of site

07.0501 Final survey

- Preparation of final survey, including:
  - Planning for final survey and sampling.

- Final survey including:
  - Specific personnel training.
  - Equipment, instrumentation calibration and testing.
  - Survey documentation.
  - Confirmatory surveys, etc.
- Administrative and/or physical controls to isolate the surveyed areas, preventing recontamination once the survey has been completed.

07.0502 Independent verification of the final survey

- Independent compliance verification with cleanup and/or site-reuse standards.
- Direct and indirect costs for independent survey.
- Presentation of results to regulators including the costs for additional sampling and revisions to report.

07.0600 Perpetuity funding/surveillance for limited or restricted release of property

07.0601 Routine maintenance

- Routine maintenance of remaining structures or buildings.
- Furnish extra cap materials, and storage area for extra cap materials.
- Site upkeep, including:
  - Mowing.
  - Maintenance.
  - Cleanup.

07.0602 Surveillance and monitoring

- Routine surveillance of:
  - Remaining structures or buildings.
  - Residual radioactivity under restricted site release conditions.
- Environmental monitoring.
- Signs, tests.

08 PROJECT MANAGEMENT, ENGINEERING AND SUPPORT

Principal Activity 08 is concerned with project management and site support services during decommissioning operations. It consists of ten Activity Groups involving the identical segments for activities performed by owner's personnel (08.0100 to 08.0500) and by contractors (08.0600 to 08.1000):

- Mobilisation and preparatory work.
- Project management.
- Support services.
- Health and safety.
- Demobilisation.
- Mobilisation and preparatory work by contractors (if needed).
- Project management by contractors (if needed).
- Support services by contractors (if needed).
- Health and safety contractors (if needed).
- Demobilisation by contractors (if needed).

The extent of the contractor's items depends on the contracting strategy implemented in the decommissioning project. Care should be taken not to duplicate the activities performed by the owner's personnel and by the contractor's.

08.0100 Mobilisation and preparatory work

08.0101 Mobilisation of personnel

- Setting up project management team.

- Setting up support staff.
- Establish decommissioning workforce.

08.0102 Establishment of general supporting infrastructure for decommissioning project

- Transport vehicles ownership/operation and drivers.
- Manifests, tolls, permits.
- Escort vehicles ownership/operation.
- Construction equipment ownership/operation and equipment operators
- Initial assembly and set-up.
- Temporary staff facilities, including:
  - Office trailers.
  - Lunch/break trailer.
  - Emergency medical trailer/facilities.
  - Storage facilities.
  - Laundry facilities.
  - Toilets.
- General technical facilities, including:
  - Photographic laboratory.
  - Equipment maintenance shop.
  - Warehouses.
  - Truck scales.
- Radiological protection laboratory.
- Decontamination facilities for construction equipment/vehicles.
- Decontamination facilities for personnel.
- Guard houses, barricades.
- Fire suppression systems, petrol, oil and lubricants dispensing station.
- Housing, shop facilities.
- Aggregate surfacing, security fencing, gates, roads and parking.
- Culverts, walks, signs, grading.
- Temporary utilities:
  - Site lighting.
  - Power connection/distribution.
  - Telephone/communications hook-up.
  - Water connection/distribution.
  - Sewer connection/distribution.
  - Gas connection/distribution.
  - Temporary relocation of roads/structures/utilities.
- Considering the contractor's on-site temporary facilities and utilities.

08.0200 Project management

08.0201 Core management group

- Decision making individuals in the owner organisation.
- Programme manager, project manager.
- General superintendent, area superintendent, chief civil engineer.
- Secretarial and/or clerical support for the higher levels of administration
- Plant management, which can be an integrated subset of the decommissioning project management team, and which is responsible for the:
  - Facility operation.
  - Facility maintenance.
  - Compliance with the existing operating licence and technical specifications.
- Continuous relationship with the:
  - Operator.

  - Authorities.
  - Expert consultants.
  - Subcontractors.
- Ongoing licensing activities.
- Craft qualification programmes, start-up programmes, permits.
- Monitoring cost development and work progress in time.

08.0202 Project implementation planning, detailed ongoing planning

- Project implementation planning:
  - Periodical evaluation of the baseline schedule for the decommissioning project.
  - Proposing the partial implementation plans based on baseline schedule
  - Proposing the performance of implementation plans by owner's personnel or by contractor's.
  - Managing the development of safety analyses, feasibility studies, cost-benefit studies, environmental analyses and other documents related to implementation plans.
  - Support for approvals of implementation plans.
  - Development of detailed implementation plans to be performed by owner's staff.
  - Tender management for implementation plans to be performed by contactors.
- Implementation plans may be organised according to:
  - Phases of the decommissioning project.
  - Contracting scheme for the decommissioning project.
  - Individual specific decommissioning activities or groups of these activities.
  - Individual buildings or groups of buildings.
  - Waste management system or its parts.
  - Procurements of specific facilities, utilities or equipment.
  - Other aspects specific for the decommissioning project.
- Detailed ongoing planning of approved implementation plans:
  - Generation of work packages.
  - Generation of detailed procedures.
  - ALARA planning.
  - Detailed costing.
- Preparation of design specifications, including specifications for:
  - Operating and maintenance procedures.
  - Waste management logistics and information system.
  - Hardware and software.
  - Installations.
  - Testing
  - Performance measurements.
  - Field modifications.
- Approvals and permits such as:
  - Procurement of specific equipment.
  - New specific individual working procedures.
  - Modification of important systems.

08.0203 Scheduling and cost control

- Activities related to approved implementation plans.
- Planners and schedulers, cost control engineers, cost accountability, drafting, and accounting personnel.
- Cost engineer and cost estimator, planning engineer, schedulers.
- CPM (critical path modelling) scheduling monthly updates.

- Providing status and accountability to the project management staff.
- Considering relationship to contractors.

08.0204 Safety and environmental analysis, ongoing studies

- Supporting documents for development of implementation plans such as:
  - Feasibility studies.
  - Safety analyses.
  - Environmental analyses.
  - Costing and cost-benefit analyses.
- Periodical re-evaluation and updating of environmental studies.
- Detailed safety analyses for:
  - Specific work packages in approved implementation plans.
  - Procurement/design, installation, testing and licensing of specific equipment for activities critical from the radiological point of view.
  - Specific individual procedures.
- Studies and safety assessments in waste management (follow-up activities of waste management planning in 01.0400) such as:
  - Waste management studies.
  - Safety analyses.
  - Hazards analyses and risk analyses for handling, packaging, storing, transporting and disposal of certain waste forms and specific radionuclides.
  - Hazards analyses, risk analyses and alternatives analyses for waste transports.
  - Waste transport feasibility studies for:
    - Large quantities.
    - Special forms.
    - Unique destinations, etc.
  - Detailed routing analyses for shipments requiring excessive clearance or weight accommodations.
  - Specific considerations concerning:
    - Package certification.
    - Shielding.
    - Local/federal review and approval, etc.
  - Considerations on the concentrations of:
  - Long-lived radionuclides, whose hazard will persist beyond the institutional controls of the disposal facility.
  - Shorter-lived radionuclides which will determine the required engineered barriers for disposal.
  - Information on how the waste will maintain its physical dimensions and form under expected disposal conditions.

08.0205 Quality assurance and quality surveillance

- Quality assurance engineers and quality control inspectors.
- Assuring conformance with established procedure(s), verification of field compliance, extended to subcontractors and vendors if safety considerations/ requirements are concerned.
- Relation to contractors.

08.0206 General administration and accounting

- Contract administrators and associated clerical support.
- Contract administrator, comptroller.
- Personnel manager, office manager, interpreter.
- Accountant, bookkeeper, timekeeper, paymaster, payroll clerks.
- Clerks, typists, receptionists, mail clerk, messengers, reproduction.

- Establishing and reviewing terms and conditions as well as assessing liabilities and exposure in the subcontracting process.
- Office supplies, mailing and shipping.
- Relation to contractors.

08.0207 Public relations and stakeholders involvement

- Focused through a representative of the facility owner (as project spokesman), although public hearing or presentations may involve many of the other personnel in the organisation.
- Public relations officer.
- Organisation of seminars, news releases, advertising, facility tours, etc.
- Visitor's centre.
- Maintaining a web page.
- Relation to contractors.

08.0300 Support services

08.0301 Engineering support

- Supporting the decommissioning process, including mechanical, electrical, instrumentation and control, heating, ventilation, air conditioning, nuclear, environmental, licensing, and civil/structural personnel.
- Project engineer, civil engineer, mechanical engineer, electrical engineer, chemical engineer.
- Scaffolders.
- Carpenter superintendent, mechanical superintendent, electrical superintendent.
- Geologist, hydrologist, scientist.
- Nuclear engineer, field engineer, surveyors, office engineer.
- Draftsman, engineering clerks and typists.
- Inspectors.
- Laboratory technicians.
- Equipment maintenance and motor pool, including:
  - Master mechanic, mechanics, mechanic helpers.
  - Spare parts manager, parts clerk.
  - Garage manager, service truck driver, vehicle equipment operator, driver, assistant.
  - Crane, lifting equipment and labour.
  - Truck scales.
  - Petrol, oil and lubricants dispensing station.
  - Waste water tanks.
- Field shop drawing service, surveying:
  - Supplies and equipment.
  - Engineering supplies and equipment.
- Mailing and shipping.
- Specific services for contractors.

08.0302 Information system and computer support

- Staff integral with the decommissioning organisation (administrators and technicians), providing support activities as equipment repair and network maintenance.
- Computer technicians.
- Computer hardware and software.
- On-call service organisations involved in providing technical support or a mainframe for running complex analyses and codes.
- Access and services for contractors.

08.0303 Waste management support

- Managing and supporting activities directly related to waste management activities.
- Establishment, procurement, operation, maintenance and decommissioning of permanent waste management system and temporary waste management facilities is in Principal Activity 05.
- Supervision, co-ordination of waste management activities such as:
  - Operation and maintenance of permanent waste management system established for the decommissioning project.
  - Retrieval of historical/legacy waste.
  - Contracted waste management activities (such as disposal).
  - Temporary waste management facilities.
  - Contractor's waste management activities.
  - Operation of contractor's on-site temporary waste management facilities.
  - Waste management logistics and information system.
- Mobilisation of waste processing staging area.
- Licences and permits for:
  - Licensing for hazardous/radiological/criticality issues.
  - Licensing for transportation issues.
  - Licensing for storage or disposal issues.
  - Obtaining state and local permits.
- Managing the interface to contractors in waste management:
  - Definition of waste management activities to be performed by contractors.
  - On-site support of the owner for contractor's waste management activities, e.g. by providing personnel trained in specific waste management activities, special materials, sample analyses, etc.
  - Enabling the use of selected parts of the owner's waste management systems by contractor's.
  - Definition of rules and measures for taking over the waste interim products from contractor's waste management activities to owner's waste management systems.
  - Taking over the contractor's waste interim products.
- Waste management detailed routing, logistics and information system:
  - Implementation.
  - Operation.
  - Maintenance.
  - Contractor's access.
- Documentation of the waste form(s) for:
  - General characteristics.
  - Free liquid content.
  - Hazardous/toxic/pyrophoric/explosive/biological constituents.
  - Identifying conditioning/treatment.
  - Traceability/accountability in the subsequent reintroduction (reuse) of the material.
- Involvement of all other aspects of the waste management system needed to cover the extent of types of historical/legacy radioactive waste additional to types of decommissioning waste.

08.0304 Decommissioning support including chemistry, decontamination

- Field/area superintendents for:
  - Work force allocation, direction, and supervision.
  - Implementing the activities as specified in the engineering and planning with the general labour workforce.

- Decontamination and chemistry technicians working under the plant operations group and involved in:
  - The control of plant chemistry.
  - Any system-wide decontamination.
- Hot laundry, including:
  - Hot laundry operations.
  - Distribution and maintenance of controlled area clothing.
- Hot sanitary.
- Specific services for contractors.

08.0305 Personnel management and training

- Personnel management and recruiting of specific decommissioning personnel and general personnel.
- Training of new personnel.
- Retraining of personnel on a periodic basis.
- Classroom instructions as well as demonstrations of proficiency in a field environment.
- Training in:
  - The use of personal protection systems as respirators.
  - The use of protective clothing.
  - The use of instrumentation.
  - Industrial safety and security.
  - Industrial/hazardous material safety.
  - Emergency management.
  - Fire fighting and first aid.
- Specific services for contractors.

08.0306 Documentation and records control

- Document control personnel or record clerks.
- Project photographs, video monitoring/recording system.
- Overseeing the control, distribution and archiving of official documentation produced in the decommissioning.
- Access and services for contractors.

08.0307 Procurement, warehousing, and materials handling

- Purchasing specialists, buyers and associated administrative personnel.
- Chief purchasing agent, purchasing agent, buyers, expediters.
- Traffic manager, travel clerks, shipping clerks.
- Inventory control manager, inventory control clerks, chief warehouse manager, receiving clerk, charge out clerk.
- Clerks and typists.
- Equipment and lifting material.
- Handling all procurement from routine supplies to contracted services.
- Emergency air freight, submittals, spare parts inventory, project signs.
- Office supplies, mailing and shipping.
- Specific services for contractors.

08.0308 Housing, office equipment, support services

- Housing and supporting the decommissioning workforce.
- Ownership of temporary construction facilities, including:
  - Office trailers and facilities, office furniture and office equipment.
  - Lunch/break trailer, emergency medical trailer/facilities.
  - Weather station.
  - Warehouse and storage trailers and facilities.
  - Laundry trailer and facilities, waste water holding tanks.

  - Construction portable toilets.
  - Photographic laboratory.
  - Equipment maintenance shop.
  - Truck scales.
  - Decontamination facilities for construction equipment/vehicles.
  - Decontamination facilities for personnel.
  - Guard houses and security shack, barricades.
  - Fire suppression systems, petrol, oil and lubricants dispensing station.
  - Housing, shop facilities.
  - Aggregate surfacing, temporary site security fencing, gates, roads and parking.
  - Culverts, walks, signs, grading.
- Operations of temporary construction facilities, including:
  - Operations manager.
  - Chefs and cooks, kitchen help, food and food supplies.
  - Janitors and cleaning services, maintenance and repair of temporary facilities.
  - Cleaning supplies, garbage services, personal items, linen supplies.
  - Laundry service.
  - Haul road maintenance, temporary parking lot maintenance.
- Maintenance of temporary facilities and utilities required in decommissioning operations, operational activities to be included in decommissioning activities, including:
  - Laundry.
  - Temporary power and/or compressed air installations.
  - Sanitary facilities, etc.
- Winterise project and temporary heat.
- Snow removal, daily site cleanup, final site cleanup.
- Protect existing property.
- Project utilities, including:
  - Telephone usage.
  - Electrical usage.
  - Sewer usage.
  - Water usage.
  - Gas usage.
- Emergency eye wash, body wash, shower.
- On site communication system.
- Medical examination, whole body counts.
- Specific services for contractors.

08.0400 Health and safety

08.0401 Health physics

- Procurement of health physics equipment for personnel dose-uptake follow-up, including installation, testing, licensing (operational activities to be included in decommissioning activities, however).
- Health physics and radiation protection personnel.
- Certified health physicist, ALARA (as low as reasonably achievable) specialist.
- Supporting the decommissioning engineering and planning as well as supervising the resulting decontamination and dismantling processes.
- Ensuring that the approach and methodologies in use are within established guidelines and accepted health and safety practices.
- Specific services for contractors.

08.0402 Industrial safety

- Safety and protection of workers in industrial environments.
- Involvement of contractor's on-site activities.
- Specific services for contractors.
- Certified industrial hygienist.
- Health and physics trainer, site safety and health officer, safety engineer, safety clerk.
- Industrial hygiene technician, air monitoring technician, respiratory specialist, safety monitor.
- Addressing the physical dangers of the work place.
- Monitoring the work force and facility during the project.
- Heat and cold stress monitoring, noise monitoring, odour monitoring.
- Conduct worker conventional safety training.
- Review implementing procedures for compliance.
- First aid, including:
  - Field doctor.
  - Field nurse.
  - Medical supplies.
  - Emergency supplies.
  - Ambulance.
  - Pilot car.
- Fire protection, including:
  - Field fire chief.
  - Field fire fighter.
  - Fire fighter supplies.
  - Fire truck.
  - Water truck.
  - Fire extinguishers.
  - Fire suppression systems.
- Traffic control, including:
  - Traffic flagmen.
  - Traffic control equipment.
  - Barricades.
- Security, including:
  - Security clerk.
  - Security chief.
  - Security officer.
  - Watchman.
  - Guards.
- Vehicles, travel and *per diem*.

08.0500 Demobilisation

08.0501 Demobilisation of project infrastructure for decommissioning

- Temporary staff facilities, including:
  - Office trailers.
  - Lunch/break trailer.
  - Emergency medical trailer/facilities.
  - Storage facilities.
  - Laundry facilities.
  - Toilets.
- General technical facilities, including:
  - Photographic laboratory.
  - Equipment maintenance shop.
  - Warehouses.

  - Truck scales.
- Radiological protection laboratory.
- Decontamination facilities for construction equipment/vehicles.
- Decontamination facilities for personnel.
- Guard houses, barricades.
- Fire suppression systems, petrol, oil and lubricants dispensing station.
- Housing, shop facilities.
- Aggregate surfacing, security fencing, gates, roads and parking.
- Culverts, walks, signs, grading.
- Removal of temporary utilities, including:
  - Site lighting.
  - Power connection/distribution.
  - Telephone/communications hook-up.
  - Water connection/distribution.
  - Sewer connection/distribution.
  - Gas connection/distribution.
- Demobilisation of construction equipment and facilities:
  - Transport vehicles ownership/operation and drivers.
  - Manifests, tolls, permits.
  - Escort vehicles ownership/operation.
  - Construction equipment ownership/operation and equipment operators.
  - Final disassembly and takedown.
- Considering the contractors on-site temporary facilities.

08.0502 Demobilisation of personnel

- Relocation of supervisory personnel.

08.0600 Mobilisation and preparatory work by contractors (if needed)

08.0601 Mobilisation of personnel

- Setting up project management team.
- Setting up support staff.
- Establish decommissioning workforce.

08.0602 Establishment of general supporting infrastructure for decommissioning project

- Transport vehicles ownership/operation and drivers.
- Manifests, tolls, permits.
- Escort vehicles ownership/operation.
- Construction equipment ownership/operation and equipment operators.
- Initial assembly and set-up.
- Temporary staff facilities, including:
  - Office trailers.
  - Lunch/break trailer.
  - Emergency medical trailer/facilities.
  - Storage facilities.
  - Laundry facilities.
  - Toilets.
- General technical facilities, including:
  - Photographic laboratory.
  - Equipment maintenance shop.
  - Warehouses.
  - Truck scales.
- Radiological protection laboratory.
- Decontamination facilities for construction equipment/vehicles.

- Decontamination facilities for personnel.
- Guard houses, barricades.
- Fire suppression systems, petrol, oil and lubricants dispensing station.
- Housing, shop facilities.
- Aggregate surfacing, security fencing, gates, roads and parking.
- Culverts, walks, signs, grading.
- Temporary utilities:
  - Site lighting.
  - Power connection/distribution.
  - Telephone/communications hook-up.
  - Water connection/distribution.
  - Sewer connection/distribution.
  - Gas connection/distribution.
  - Temporary relocation of roads/structures/utilities.
- Considering the contractor's on-site temporary facilities and utilities.

08.0700 Project management by contractors (if needed)

08.0701 Core management group

- Decision making individuals in the contractors' organisations.
- Programme manager, project manager.
- General superintendent, area superintendent, chief civil engineer.
- Secretarial and/or clerical support for the higher levels of administration.
- Plant management, which can be an integrated subset of the decommissioning project management team, and which is responsible for the:
  - Facility operation.
  - Facility maintenance.
  - Compliance with the existing operating licence and technical specifications.
- Continuous relationship with the:
  - Operator.
  - Authorities.
  - Expert consultants.
  - Owner.
  - Subcontractors.
- Ongoing licensing activities.
- Craft qualification programmes, start-up programmes, permits.
- Monitoring cost development and work progress in time.

08.0702 Project implementation planning, detailed ongoing planning

- Project implementation planning:
  - Developing the bids.
  - Participation in tendering.
- Detailed ongoing planning of approved implementation plans:
  - Generation of work packages.
  - Generation of detailed procedures.
  - ALARA planning.
  - Detailed costing.

08.0703 Scheduling and cost control

- Activities related to approved implementation plans.
- Planners and schedulers, cost control engineers, cost accountability, drafting, and accounting personnel.
- Cost engineer and cost estimator, planning engineer, schedulers.

- CPM (Critical Path Modelling) scheduling monthly updates.
- Providing status and accountability to the project management staff.
- Considering relationship to owner and other contractors.

08.0704 Safety and environmental analysis, ongoing studies

- Supporting documents for development of implementation plans such as:
  - Feasibility studies.
  - Safety analyses.
  - Environmental analyses.
  - Costing and cost-benefit analyses.
- Periodical re-evaluation and updating of environmental studies.
- Detailed safety analyses for:
  - Specific work packages in approved implementation plans.
  - Procurement/design, installation, testing and licensing of specific equipment for activities critical from the radiological point of view.
  - Specific individual procedures.
- Studies and safety assessments in waste management (follow-up activities of waste management planning in 01.0400) such as:
  - Waste management studies.
  - Safety analyses.
  - Hazard analyses and risk analyses for handling, packaging, storing, transporting and disposal of certain waste forms and specific radionuclides.
  - Hazard analyses, risk analyses and alternatives analyses for waste transports.
  - Waste transport feasibility studies for:
    - Large quantities.
    - Special forms.
    - Unique destinations, etc.
  - Detailed routing analyses for shipments requiring excessive clearance or weight accommodations.
  - Specific considerations concerning:
    - Package certification.
    - Shielding.
    - Local/federal review and approval, etc.
  - Considerations on the concentrations of:
    - Long-lived radionuclides, whose hazard will persist beyond the institutional controls of the disposal facility.
    - Shorter-lived radionuclides which will determine the required engineered barriers for disposal.
  - Information on how the waste will maintain its physical dimensions and form under expected disposal conditions.

08.0705 Quality assurance and quality surveillance

- Quality assurance engineers and quality control inspectors.
- Assuring conformance with established procedure(s), verification of field compliance, extended to subcontractors and vendors if safety considerations/ requirements are concerned.
- Relation to owner and other contractors.

08.0706 General administration and accounting

- Contract administrators and associated clerical support.
- Contract administrator, comptroller.
- Personnel manager, office manager, interpreter.
- Accountant, bookkeeper, timekeeper, paymaster, payroll clerks.

- Clerks, typists, receptionists, mail clerk, messengers, reproduction.
- Establishing and reviewing terms and conditions as well as assessing liabilities and exposure in the subcontracting process.
- Office supplies, mailing and shipping.
- Relation to owner and other contractors.

08.0707 Public relations and stakeholders involvement

- Focused through a representative of the facility owner (as project spokesman), although public hearing or presentations may involve many of the other personnel in the organisation.
- Public relations officer.
- Organisation of seminars, news releases, advertising, facility tours, etc.
- Visitor's centre.
- Maintaining a web page.
- Relation to owner and other contractors.

08.0800 Support services by contractors (if needed)

08.0801 Engineering support

- Supporting the decommissioning process, including mechanical, electrical, instrumentation and control, heating, ventilation, air conditioning, nuclear, environmental, licensing, and civil/structural personnel.
- Project engineer, civil engineer, mechanical engineer, electrical engineer, chemical engineer.
- Scaffolders.
- Carpenter superintendent, mechanical superintendent, electrical superintendent.
- Geologist, hydrologist, scientist.
- Nuclear engineer, field engineer, surveyors, office engineer.
- Draftsman, engineering clerks and typists.
- Inspectors.
- Laboratory technicians.
- Equipment maintenance and motor pool, including:
  - Master mechanic, mechanics, mechanic helpers.
  - Spare parts manager, parts clerk.
  - Garage manager, service truck driver, vehicle equipment operator, driver, assistant.
  - Crane, lifting equipment and labour.
  - Truck scales.
  - Petrol, oil and lubricants dispensing station
  - Waste water tanks.
- Field shop drawing service, surveying:
  - Supplies and equipment.
  - Engineering supplies and equipment.
- Supporting the development of the “decommissioning plan”, including:
  - Generation of work packages (for bid).
  - Generation of detailed procedures.
  - Safety analyses.
  - Cost-benefit/feasibility studies.
  - Field modifications, etc.
  - Mailing and shipping.
- Specific services for owner and other contractors.

08.0802 Information system and computer support

- Staff integral with the decommissioning organisation (administrators and technicians), providing support activities as equipment repair and network maintenance.
- Computer technicians.
- Computer hardware and software.
- On-call service organisations involved in providing technical support or a mainframe for running complex analyses and codes.
- Access and specific services for owner and other contractors.

08.0803 Waste management support

- Managing and supporting activities directly related to waste management activities.
- Establishment, procurement, operation, maintenance and decommissioning of contractor's waste management system and temporary waste management facilities is in Principal Activity 05.
- Supervision, co-ordination of waste management activities such as:
  - Operation and maintenance of permanent waste management system established for the decommissioning project.
  - Retrieval of historical/legacy waste.
  - Contracted waste management activities (such as disposal).
  - Temporary waste management facilities.
  - Contractor's waste management activities.
  - Operation of contractor's on-site temporary waste management facilities.
  - Waste management logistics and information system.
- Mobilisation of waste processing staging area.
- Licenses and permits for:
  - Licensing for hazardous/radiological/criticality issues.
  - Licensing for transportation issues.
  - Licensing for storage or disposal issues.
  - Obtaining State and local permits.
- Managing the interface to owner and other contractors in waste management:
  - Definition of waste management activities to be performed by contractors.
  - On-site support for the owner and other contractor's waste management activities, e.g. by providing the personnel trained in specific waste management activities, special materials, sample analyses, etc.
  - Enabling the use of selected parts of the contractor's waste management systems by owner and other contractors.
  - Definition of rules and measures for taking over the waste interim products from contractor's waste management activities to owner's waste management systems.
  - Handing over the contractor's waste interim products to owner.
- Waste management detailed routing, logistics and information system:
  - Implementation.
  - Operation.
  - Maintenance.
  - Owners and other contractor's access.
- Documentation of the waste form(s) for:
  - General characteristics.
  - Free liquid content.
  - Hazardous/toxic/pyrophoric/explosive/biological constituents.
  - Identifying conditioning/treatment.
  - Traceability/accountability in the subsequent reintroduction (reuse) of the material.

- Involvement of all other aspects of the waste management system needed to cover the extent of types of historical/legacy radioactive waste additional to types of decommissioning waste.

08.0804 Decommissioning support including chemistry, decontamination

- Field/area superintendents for:
  - Work force allocation, direction, and supervision.
  - Implementing the activities as specified in the engineering and planning with the general labour workforce.
- Decontamination and chemistry technicians working under the plant operations group and involved in:
  - The control of plant chemistry.
  - Any system-wide decontamination.
- Hot laundry, including:
  - Hot laundry operations.
  - Distribution and maintenance of controlled area clothing.
- Hot sanitary.
- Specific services for owner and other contractors.

08.0805 Personnel management and training

- Training of new personnel.
- Retraining of personnel on a periodic basis.
- Classroom instructions as well as demonstrations of proficiency in a field environment.
- Training in:
  - The use of personal protection systems as respirators.
  - The use of protective clothing.
  - The use of instrumentation.
  - Industrial safety and security.
  - Industrial/hazardous material safety.
  - Emergency management.
  - Fire fighting and first aid.
- Specific services for owner and other contractors.

08.0806 Documentation and records control

- Document control personnel or record clerks.
- Project photographs, video monitoring/recording system.
- Overseeing the control, distribution and archiving of official documentation produced in the decommissioning.
- Specific services for owner and other contractors.

08.0807 Procurement, warehousing and materials handling

- Purchasing specialists, buyers and associated administrative personnel.
- Chief purchasing agent, purchasing agent, buyers, expediters.
- Traffic manager, travel clerks, shipping clerks.
- Inventory control manager, inventory control clerks, chief warehouse manager, receiving clerk, charge out clerk.
- Storekeeper, assistants.
- Clerks and typists.
- Equipment and lifting material.
- Handling all procurement from routine supplies to contracted services.
- Emergency air freight, submittals, spare parts inventory, project signs.
- Office supplies, mailing and shipping.
- Specific services for owner and other contractors.

08.0808 Housing, office equipment, support services

- Housing and supporting the decommissioning workforce.
- Ownership of temporary construction facilities, including:
  - Office trailers and facilities, office furniture and office equipment.
  - Lunch/break trailer, emergency medical trailer/facilities.
  - Weather station.
  - Warehouse and storage trailers and facilities.
  - Laundry trailer and facilities, waste water holding tanks.
  - Construction portable toilets.
  - Photographic laboratory.
  - Equipment maintenance shop.
  - Truck scales.
  - Decontamination facilities for construction equipment/vehicles.
  - Decontamination facilities for personnel.
  - Guard houses and security shack, barricades.
  - Fire suppression systems, petrol, oil and lubricants dispensing station.
  - Housing, shop facilities.
  - Aggregate surfacing, temporary site security fencing, gates, roads and parking.
  - Culverts, walks, signs, grading.
- Operations of temporary construction facilities, including:
  - Operations manager.
  - Chefs and cooks, kitchen help, food and food supplies.
  - Janitors and cleaning services, maintenance and repair of temporary facilities.
  - Cleaning supplies, garbage services, personal items, linen supplies
  - Laundry service.
  - Haul road maintenance, temporary parking lot maintenance.
- Maintenance of temporary facilities and utilities required in decommissioning operations, operational activities to be included in decommissioning activities, including:
  - Laundry.
  - Temporary power and/or compressed air installations.
  - Sanitary facilities, etc.
- Winterise project and temporary heat.
- Snow removal, daily site clean-up, final site clean-up.
- Protect existing property.
- Project utilities, including:
  - Telephone usage.
  - Electrical usage.
  - Sewer usage.
  - Water usage.
  - Gas usage.
- Emergency eye wash, body wash, shower.
- On site communication system.
- Medical examination, whole body counts.
- Specific services for owner and other contractors.

08.0900 Health and safety by contractors (if needed)

08.0901 Health physics

- Procurement of health physics equipment for personnel dose-uptake follow-up, including installation, testing, licensing (operational activities to be included in decommissioning activities, however).
- Health physics and radiation protection personnel.

- Certified health physicist, ALARA specialist.
- Supporting the decommissioning engineering and planning as well as supervising the resulting decontamination and dismantling processes.
- Ensuring that the approach and methodologies in use are within established guidelines and accepted health and safety practices.
- Specific services for owner and other contractors.

08.0902 Industrial safety

- Safety and protection of workers in industrial environments.
- Involvement of contractor's on-site activities.
- Specific services for owner and other contractors.
- Certified industrial hygienist.
- Health and physics trainer, site safety and health officer, safety engineer, safety clerk.
- Industrial hygiene technician, air monitoring technician, respiratory specialist, safety monitor.
- Addressing the physical dangers of the work place.
- Monitoring the work force and facility during the project.
- Heat and cold stress monitoring, noise monitoring, odour monitoring.
- Conduct worker conventional safety training.
- Review implementing procedures for compliance.
- First aid, including:
  - Field doctor.
  - Field nurse.
  - Medical supplies.
  - Emergency supplies.
  - Ambulance.
  - Pilot car.
- Fire protection, including:
  - Field fire chief.
  - Field fire fighter.
  - Fire fighter supplies.
  - Fire truck.
  - Water truck.
  - Fire extinguishers.
  - Fire suppression systems.
- Traffic control, including:
  - Traffic flagmen.
  - Traffic control equipment.
  - Barricades.
- Security, including:
  - Security clerk.
  - Security chief.
  - Security officer
  - Watchman
  - Guards.
- Vehicles, travel and *per diem*.

08.1000 Demobilisation by contractors (if needed)

08.1001 Demobilisation of project infrastructure for decommissioning

- Temporary staff facilities, including:
  - Office trailers.
  - Lunch/break trailer.
  - Emergency medical trailer/facilities.

  - Storage facilities.
  - Laundry facilities.
  - Toilets.
- General technical facilities, including:
  - Photographic laboratory.
  - Equipment maintenance shop.
  - Warehouses.
  - Truck scales.
- Radiological protection laboratory.
- Decontamination facilities for construction equipment/vehicles.
- Decontamination facilities for personnel.
- Guard houses, barricades.
- Fire suppression systems, petrol, oil and lubricants dispensing station.
- Housing, shop facilities.
- Aggregate surfacing, security fencing, gates, roads and parking.
- Culverts, walks, signs, grading.
- Removal of temporary utilities, including:
  - Site lighting.
  - Power connection/distribution.
  - Telephone/communications hook-up.
  - Water connection/distribution.
  - Sewer connection/distribution.
  - Gas connection/distribution.
- Demobilisation of construction equipment and facilities:
  - Transport vehicles ownership/operation and drivers.
  - Manifests, tolls, permits.
  - Escort vehicles ownership/operation.
  - Construction equipment ownership/operation and equipment operators.
  - Final disassembly and takedown
- Considering the owner's and other contractors' on-site temporary facilities.

08.1002 Demobilisation of personnel

- Relocation of supervisory personnel.

09 RESEARCH AND DEVELOPMENT

Principal Activity 09 comprises research and development of decommissioning techniques and technologies:

- Research and development of equipment, techniques and procedures.
- Simulation of complicated works.

Principal Activity 09 is concerned with providing new knowledge, data, equipment, techniques, procedures and computer codes which are not available in order to manage any specific conditions identified within decommissioning projects.

Activities related to design, construction, adaptation of specific equipment, techniques, procedures and tooling based on existing knowledge, experience and data are involved in relevant cost items.

09.0100 Research and development of equipment, techniques and procedures

09.0101 Equipment, techniques and procedures for characterisation

- Research and development of specific measurement devices adapted to decommissioning project.

- Research and development of specific calculation and evaluation procedures, and computer codes.

09.0102 Equipment, techniques and procedures for decontamination

- Research and development of new decontamination techniques for use within the decommissioning project.

09.0103 Equipment, techniques and procedures for dismantling

- Research and development of new dismantling equipment.
- Research and development on:
  - Remotely operated systems.
  - Robotics and manipulators.

09.0104 Equipment, techniques and procedures for waste management

- Research and development of adapted waste treatment techniques.
- Research and development related to disposal of waste.
- Research and development of:
  - Computer codes for radioactive inventory estimation.
  - Disposal facility performance codes and safety assessment codes.
- Research and development and status review to determine the actual positions for:
  - Free release of materials.
  - Restricted release of materials for dedicated purposes.

09.0105 Other research and development activities

- Searching for general information, including:
  - Literature review.
  - Data collection.
  - Considerations on actual and future dismantling and decontamination strategies and techniques.
- Status review to determine the actual positions for:
  - Comparative work in the world.
  - Identification of extent of research and development activities for decommissioning project.
- Development of project management computer code systems.
- Generation of specifications for new equipment, techniques, software codes, procedures.
- Other.

09.0200 Simulation of complicated works

09.0201 Physical mock-ups and training

- Use of mock-ups in relation to manufacturing, design, adaptation:
  - Scale models and demonstrations.
  - Adaptation of existing tooling.
  - Manufacturing processes or related applications.
  - Simulations.
- Use of mock-ups for training purposes:
  - Training for work in exposed areas.

09.0202 Consultancy.

09.0203 Test or demonstration programmes

- Test and demonstration programmes for new developed procedures, equipment, techniques.
- Test and demonstration programmes for complex procedures to be implemented in the decommissioning project.

09.0204 Computer simulations, visualisations and 3D modelling

- Development of complex working procedures.
- Increasing the efficiency of work procedures.
- ALARA planning for activities in highly exposed areas.
- Support for research and development of equipment, techniques, procedures, etc.

09.0205 Other activities

10 FUEL AND NUCLEAR MATERIAL

Principal Activity 10 is concerned with the removal of spent fuel elements, assemblies and/or nuclear material, but excluding costs for reprocessing or final disposal alternatives:

- Removal of fuel or nuclear materials from facility to be decommissioned.
- Dedicated buffer storage for fuel and/or nuclear materials.
- Decommissioning of buffer storage.

Two basic alternatives are covered in Principal Activity 10:

- Spent fuel and nuclear materials may be transported to existing external storage facilities outside of the scope of the decommissioning project. In these cases, the decommissioning projects involve only Activity 10.0101 which means the transporting of spent fuel and nuclear materials away from facilities.
- It is not possible to transport the spent fuel and nuclear materials to external storage facilities outside of the scope of the decommissioning project. In order to enable to start the decommissioning of the facility, dedicated buffer storage is required, which is part of the decommissioning project. In these cases, the decommissioning project involves the Activities 10.0102-10.0302; the extent of use of these items depends on definition of the scope of the decommissioning project.

10.0100 Removal of fuel or nuclear material from facility to be decommissioned

10.0101 Transfer of fuel or nuclear material to external storage or to treatment facilities

- Procurement of additional equipment required for transport to external storage of all fuel or nuclear material, including:
  - Cribs.
  - Sealed bottles, etc.
- Consideration of safety measures related to transfer.
- Consideration of safety measures for transportation.
- Transfer of fuel assemblies or nuclear material using transport cask or transport containers.
- Arrangements for ensuring the safety of transports including the security aspects.

10.0102 Transfer of fuel or nuclear material to dedicated buffer store

- Procurement of additional equipment required for transport to external storage of all fuel or nuclear material, including:
  - Cribs.
  - Sealed bottles, etc.
- Consideration of safety measures related to transfer.
- Consideration of safety measures for transportation.

- Transfer of fuel assemblies or nuclear material using transport cask or transport containers.
- Arrangements for ensuring the safety of transports including the security aspects.

10.0200 Dedicated buffer storage for fuel and/or nuclear material

10.0201 Construction of buffer storage

- Design, construction and licensing.

10.0202 Operation of buffer storage

- Operation
- Maintenance and periodical inspection.

10.0203 Transfer of fuel and/or nuclear material away from the buffer storage

- Procurement of additional equipment required for transport to external storage of all fuel or nuclear material, including:
  - Cribs.
  - Sealed bottles, etc.
- Consideration of safety measures related to transfer.
- Consideration of safety measures for transportation.
- Transfer of fuel assemblies or nuclear material using transport cask or transport containers.
- Arrangements for ensuring the safety of transports including the security aspects.

10.0300 Decommissioning of buffer storage

10.0301 Decommissioning of buffer storage

- Decontamination of storage modules.
- Remediation of any contaminated hardware of storage.
- Remediation of activated materials of storage.
- Dismantling of facility.
- Radioactivity survey.
- Demolition of buildings and site remediation.

10.0302 Management of waste

- Processing of waste from decontamination and dismantling.
- Disposal of radioactive waste.
- Management of hazardous waste.
- Management of conventional waste.

11 MISCELLANEOUS EXPENDITURES

Principal Activity 11 is concerned with costs that cannot be specifically classified in the foregoing sections:

- Owner costs.
- Taxes.
- Insurances.
- Asset recovery.

11.0100 Owner costs

Activity Group 11.0100 covers all other activities related to decommissioning project that cannot be directly allocated to previous sections.

11.0101 *Implementation of transition plans*

- Implementation of shutdown plans for orderly progression from operations to decommissioning.
- Staff reduction according to individual phases from operation to decommissioning.
- Re-assignment/training for operational personnel used for decommissioning activities.
- Key employee retention/incentive programmes.
- Other activities.

11.0102 *External projects to be performed as a consequence of decommissioning*

- Projects not involved directly in decommissioning activities of the decommissioning project but needed for compensating the consequences of shutdown at:
  - Site level.
  - Local municipal level.
  - Other levels.

11.0103 *Payments (fees) to authorities*

- Payments/fees to authorities not directly allocated to Sections 01-10.

11.0104 *Specific external services and payments*

- Specific external services not directly allocated to Sections 01-10 such as:
  - Consultancy, administration.
  - Reviews, reports.
  - Inspections, certifications.
  - Involvement of stakeholders.
- Specific external payments not directly allocated to sections 01-10 such as:
  - Rents.
  - Fixed cost related to decommissioning.
  - Fixed cost related to stakeholders.
  - Contributions to local foundations, etc.

11.0200 Taxes

11.0201 *Value added taxes*

- Value added taxes according to relevant national legislation.

11.0202 *Local, community, federal taxes*

- Any local, community and federal taxes according to relevant national legislation.

11.0203 *Environmental taxes*

- Any environmental taxes according to relevant national legislation.

11.0204 *Taxes on industrial activities*

- Any taxes related to industrial activities according to relevant national legislation.

11.0205 *Other taxes*

- Any other taxes to relevant national legislation.

11.0300 Insurances

11.0301 *Nuclear related insurances*

- Liability insurance.

- Pollution liability insurance.
- Insurance in preparatory, dormancy and dismantling periods.

11.0302 Other insurances

- Builders risk insurance.
- Equipment floater insurance.
- Marine insurance.
- Home office (general and administrative) insurance.

11.0400 Asset recovery

11.0401 Asset recovery related to redundant equipment

- Sale or transfer of general site dismantling equipment such as:
  - Overhead cranes.
  - Jib cranes.
  - Forklift trucks.
  - Trucks.
  - Security fences, etc.
- Sale or transfer of equipment for personnel and/or tooling decontamination.
- Sale or transfer of:
  - Radiation protection equipment.
  - Monitoring equipment for dose-rate measurements.
  - Contamination measurements.
  - Decommissioning operations and/or material release measurements.
  - Health physics equipment for personnel dose-uptake follow-up.
- Resale/transfer of facility equipment and components as well as surplus inventory to other licensed (contaminated) and unlicensed (non-contaminated) facilities.
- Sale or transfer of "active" equipment and surplus spare parts of the facility to other nuclear facilities.
- Sale or transfer of salvaged equipment and/or components that have been decontaminated or cleaned to the established criteria for future use in other classified or non-classified installations.

11.0402 Asset recovery related to released materials

- Sale or transfer of scrap and/or materials that have been decontaminated or cleaned to the established criteria at which recycling and reuse is permitted.

11.0403 Asset recovery related to material and equipment from conventional dismantling and demolition

- Sale or transfer of non-contaminated equipment and surplus spare parts of the facility to other nuclear or non-classified installations.
- Sale or transfer of recycled materials.

11.0404 Asset recovery related to buildings and site

- Sale of buildings that have been cleaned/refurbished and released for unrestricted use.
- Sale of buildings that have been approved for restricted use.
- Sale of site or its parts.

11.0405 Other asset recovery

- Other assets not identified in previous items.

Standardised definitions for cost categories (all major activities)

For each cost item, four cost categories have been defined:

- Labour costs.
- Investment costs (capital, equipment and material costs).
- Expenses.
- Contingency.

Labour costs

Labour costs are defined as costs calculated on the basis of the workload for a particular cost item and the labour cost unit rate, including:

- Salaries.
- Contributions to social security and health insurance.
- Company contributions to pension scheme and fringe benefits.
- Overheads.

Investment costs (capital, equipment and material costs)

Investment costs are defined as costs for:

- Equipment to be used for a particular cost item.
- Machinery to be used for a particular cost item.

Expenses

Expenses are defined as costs for consumer items or expendable items, or as costs for other expenditures related to decommissioning cost items where applicable, as for:

- Consumables.
- Spare parts.
- Protective clothing.
- Travel expenses.
- Legal expenses.
- Taxes.
- Value added tax.
- Insurance.
- Consultants costs.
- Quality assurance costs.
- Rents.
- Office material.
- Heating costs.
- Water costs.
- Electricity costs.
- Computer costs.
- Telephone/fax costs.
- Cleaning.
- Interest.
- Public relation.
- Licences/patents.
- Decommissioning authorisation.
- Income from asset recovery ("negative expenses").

Contingency

Contingency, added to individual cost items of the standardised listing, is a specific provision for unforeseeable elements of costs within the defined project scope. Any impacts on cost outside of the scope of the decommissioning project are not considered.

Contingencies related to risk assessment of the calculated cost (risk contingency) is not included here as this is concerned with risks resulting from situations which would themselves alter the scope of the project, e.g. changes in national legislation. Cost estimates developed according to this structure may be used as basis for calculating such contingencies, though care should be taken to avoid confusion with contingency sums developed as part of the main cost estimate, using the cost structure provided in this document.

Appendix E: Glossary

The purpose of this glossary is to provide a source of words which are commonly used or have special meanings in this document. However, it should be noted that some terms are used and defined differently in other areas of technology.

Technical terms used in only one country are not included. A few terms relating to the financial and social aspects of decommissioning are listed, but these areas have not been covered in any depth.

In the organisation of the glossary, the use of modifiers (e.g. adverbs and adjectives) has been kept to a minimum. Many phrases are indexed under the key word in the phrase. For example, the term "radioactive waste" appears under waste, radioactive.

In the context of this glossary, the term "waste" refers, in general, to radioactive waste unless otherwise specified.

More detailed technical terms are provided in the following references:

1. IAEA Safety Glossary: Terminology Used in Nuclear Safety and Radiation Protection: 2007 Edition, International Atomic Energy Agency, Vienna, 2007.
2. IAEA Radioactive Waste Management Glossary: 2003 Edition, International Atomic Energy Agency, Vienna, 2003.

accident	Any unintended event, including operating errors, equipment failures and other mishaps, the consequences or potential consequences of which are not negligible from the point of view of protection or safety.
activity	(See: *radioactivity*)
analysis	Often used interchangeably with assessment, especially in more specific terms such as "safety analysis". In general, however, analysis suggests the process and result of a study aimed at understanding the subject of the analysis, while assessment may also include determinations or judgements of acceptability. Analysis is also often associated with the use of a specific technique. Hence, one or more forms of analysis may be used in assessment.
area, controlled	A defined area in which specific protection measures and safety provisions are or could be required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures.
assessment	The process, and the result, of analysing systematically and evaluating the hazards associated with sources and practices, and associated protection and safety measures.

authorisation The granting by a regulatory body or other governmental body of written permission for an operator to perform specified activities.

barrier A physical obstruction that prevents or inhibits the movement of people, radionuclides or some other phenomenon (e.g. fire), or provides shielding against radiation.

cask A vessel for the transport and/or storage of spent fuel and other radioactive materials. The cask serves several functions. It provides chemical, mechanical, thermal and radiological protection, and dissipates decay heat during handling, transport and storage

characterisation (See: *waste characterisation*)

clearance Either

a) Removal of radioactive material or radioactive objects within authorised practices from any further regulatory control by the regulatory body.

b) The net effect of the biological processes by which radionuclides are removed from a tissue, organ or area of the body.

commissioning The process by means of which systems and components of facilities and activities, having been constructed, are made operational and verified to be in accordance with the design and to have met the required performance criteria.

compaction Either:

a) A treatment method where the bulk volume of a compressible material is reduced by application of external pressure – hence an increase in its density (mass per unit volume).

b) Compaction of soil materials covering a near-surface disposal facility to reduce the soil permeability.

conditioning Those operations that produce a waste package suitable for handling, transport, storage and/or disposal. Conditioning may include the conversion of the waste to a solid waste form, enclosure of the waste in containers and, if necessary, provision of an overpack.

container, waste The vessel into which the waste form is placed for handling, transport, storage and/or eventual disposal; also the outer barrier protecting the waste from external intrusions. The waste container is a component of the waste package. For example, molten high-level waste glass would be poured into a specially designed container (canister), where it would cool and solidify.

containment	Methods or physical structures designed to prevent or control the release and the dispersion of radioactive substances.
contamination	Radioactive substances on surfaces, or within solids, liquids or gases (including the human body), where their presence is unintended or undesirable, or the process giving rise to their presence in such places.
controlled area	(See: *area, controlled*)
cost category	Cost items include the following distinct types of costs: a) labour costs; b) capital, equipment and material costs (= investment costs); c) expenses; d) contingency.
cost item	The smallest general or specific decommissioning activities where decommissioning costs are calculated.
decommissioning	Administrative and technical actions taken to allow the removal of some or all of the regulatory controls from a facility (except for a repository or for certain nuclear facilities used for the disposal of residues from the mining and processing of radioactive material, which are "closed" and not "decommissioned").
decommissioning option	One of various decommissioning strategies which may be considered when decommissioning is being planned. A variety of factors, such as timing and the availability of technologies, will influence which decommissioning strategy is ultimately chosen.
decommissioning phase	Well defined and discrete set of activities within the decommissioning process.
decommissioning waste	(See *waste, decommissioning*)
decontamination	The complete or partial removal of contamination by a deliberate physical, chemical or biological process.
demolition	The removal of a building or structure, including its contents, by any appropriate method which may involve destructive methods and techniques.
dismantling	The disassembly and removal of any structure, system or component during decommissioning. Dismantling may be performed immediately after permanent retirement of a nuclear facility or it may be deferred.
disposal	Emplacement of waste in an appropriate facility without the intention of retrieval.

enclosure, safe	A condition of a nuclear facility during the decommissioning process in which only surveillance and maintenance of the facility take place (see also *decommissioning phase*).
entombment	Disposal of the nuclear facility or portions thereof within the nuclear site boundary. It includes *in situ* disposal (entombment) where the nuclear facility is disposed wholly or partly at its existing location; or on-site transfer and disposal where the nuclear facility or portions thereof are moved to a repository at an adjacent location on the site.
exempt waste (EW)	[See: *waste, exempt (EW)*]
exposure	The act or condition of being subject to irradiation.
facilities	Facilities includes: nuclear facilities; irradiation installations; some mining and raw material processing facilities such as uranium mines; radioactive waste management facilities; and any other places where radioactive material is produced, processed, used, handled, stored or disposed of — or where radiation generators are installed — on such a scale that consideration of protection and safety is required.
high-level waste (HLW)	[See: *waste, high-level (HLW)*]
historical/legacy waste	Waste remaining in the facility from the facility operation.
installation	(See: *nuclear facility* or *facilities*)
institutional control	Control of a radioactive waste site by an authority or institution designated under the laws of a state. This control may be active (monitoring, surveillance, remedial work) or passive (land use control) and may be a factor in the design of a nuclear facility (e.g. near-surface repository).
Intermediate-level waste (ILW)	[See *waste, intermediate-level (ILW)*]
licence	A legal document issued by the regulatory body granting authorisation to perform specified activities related to a facility or activity.
low-level waste (LLW)	[See *waste, low-level (LLW)*]
monitoring	Continuous or periodic measurement of radiological and other parameters or determination of the status of a system.
nuclear facility	A facility and its associated land, buildings and equipment in which radioactive materials are produced, processed, used, handled, stored or disposed of on such a scale that consideration of safety is required.

nuclear fuel	Fissionable nuclear material in the form of fabricated elements for loading into the reactor core of a civil nuclear power plant or research reactor.
nuclear material	Plutonium except that with isotopic concentration exceeding 80% in plutonium-238; uranium-233; uranium enriched in the isotope 235 or 233; uranium containing the mixture of isotopes as occurring in nature other than in the form of ore or ore residue; any material containing one or more of the foregoing.
package, waste	The product of conditioning that includes the waste form and any container(s) and internal barriers (e.g. absorbing materials and liners), prepared in accordance with the requirements for handling, transport, storage and/or disposal.
packaging	The assembly of components necessary to enclose the radioactive contents completely. It may, in particular, consist of one or more receptacles, absorbent materials, spacing structures, radiation shielding and service equipment for filling, emptying, venting and pressure relief; devices for cooling, absorbing mechanical shocks, handling and tie down, and thermal insulation; and service devices integral to the package. The packaging may be a box, drum or similar receptacle, or may also be a freight container, tank or intermediate bulk container.
practice	Any human activity that introduces additional sources of exposure or additional exposure pathways, or extends exposure to additional people, or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed.
processing, waste	Any operation that changes the characteristics of waste, including pre-treatment, treatment and conditioning.
quality assurance	The function of a management system that provides confidence that specified requirements will be fulfilled.
quality control	Part of quality assurance intended to verify that structures, systems and components correspond to predetermined requirements.
radiation protection or radiological protection	The protection of people from the effects of exposure to ionizing radiation, and the means for achieving this.
radiological survey	(See: *survey, radiological*)
radioactive waste	(See: *waste, radioactive*)
radioactivity	The phenomenon whereby atoms undergo spontaneous random disintegration, usually accompanied by the emission of radiation.

records — A set of documents, such as instrument charts, certificates, log books, computer printouts and magnetic tapes for each nuclear facility, organised in such a way that it provides past and present representations of facility operations and activities including all phases from design through closure and decommissioning (if the facility has been decommissioned). Records are an essential part of quality assurance.

recycling — The reutilisation of materials and equipment in subsequent operations after transformation, i.e. for metals, after melting and recycling of the ingots.

repository — A nuclear facility where waste is emplaced for disposal. Repositories are either:

a) geological repository. A facility for radioactive waste disposal located underground (usually several hundred metres or more below the surface) in a stable geological formation to provide long term isolation of radionuclides from the biosphere.

b) near-surface repository. A facility for radioactive waste disposal located at or within a few tens of meters of the Earth's surface.

reuse — The re-utilisation of materials and equipment in subsequent operations in their original form, without any further transformation, i.e., for tanks, pumps, motors, valves, chemical reagents, process materials, etc.

risk — Either:

a) A multi-attribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with actual or potential exposures. It relates to quantities such as the probability that specific deleterious consequences may arise and the magnitude and character of such consequences.

b) The mathematical mean (expectation value) of an appropriate measure of a specified (usually unwelcome) consequence.

safe enclosure — (See: *enclosure, safe*)

shielding — A material interposed between a source of radiation and persons, or equipment or other objects, in order to absorb radiation and thereby reduce radiation exposure.

shutdown — The permanent or temporary termination of a process or operation.

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

spent fuel	Nuclear fuel that has been irradiated in and permanently removed from a reactor core.
stakeholder	Interested party; concerned party.
storage	The holding of spent fuel or of radioactive waste in a facility that provides for its containment, with the intention of retrieval. Storage is by definition an interim measure, and the term interim storage would therefore be appropriate only to refer to short term temporary storage when contrasting this with the longer term fate of the waste. Storage as defined above should not be described as interim storage.
surveillance	Activities performed to ensure that conditions at a nuclear facility remain within the authorised limits. For a near-surface repository, surveillance normally continues past the periods of operation and closure.
survey, radiological	An evaluation of the radiological conditions and potential hazards associated with the production, use, transfer, release, disposal, or presence of radioactive material or other sources of radiation.
transportation	The deliberate physical movement of radioactive material (other than that forming part of the means of propulsion) from one place to another.
treatment	Operations intended to benefit safety and/or economy by changing the characteristics of the waste. Three basic treatment objectives are: volume reduction, removal of radionuclides from the waste and change of composition. Treatment may result in an appropriate waste form.
very low-level waste (VLLW)	[See: *waste, very low-level (VLLW)*]
very short-lived waste (VSLW)	[See: *waste, very short-lived (VSLW)*]
waste	Material for which no further use is foreseen.
waste, decommissioning	Any radioactive waste from decommissioning activities.
waste, exempt (EW)	Waste that meets the criteria for clearance, exemption or exclusion from regulatory control for radiation protection purposes. This item may involve also reusable materials.
waste, high-level (HLW)	Waste with levels of activity concentration high enough to generate significant quantities of heat by the radioactive decay process or waste with large amounts of long-lived radionuclides that need to be considered in the design of a disposal facility for such waste.

waste, intermediate-level (ILW) Waste that, because of its content, particularly of long-lived radionuclides, requires a greater degree of containment and isolation than that provided by near-surface disposal. However, ILW needs no provision, or only limited provision, for heat dissipation during its storage and disposal. ILW may contain long-lived radionuclides, in particular, alpha-emitting radionuclides that will not decay to a level of activity concentration acceptable for near-surface disposal during the time for which institutional controls can be relied upon. Therefore, waste in this class requires disposal at greater depths, of the order of tens of metres to a few hundred metres.

waste, low-level (LLW) Waste that is above clearance levels, but with limited amounts of long-lived radionuclides. Such waste requires robust isolation and containment for periods of up to a few hundred years and is suitable for disposal in engineered near-surface facilities. This class covers a very broad range of waste. LLW may include short-lived radionuclides at higher levels of activity concentration, and also long-lived radionuclides, but only at relatively low levels of activity concentration.

waste, radioactive For legal and regulatory purposes, waste that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels as established by the regulatory body.

waste, very low-level (VLLW) Waste that does not necessarily meet the criteria of EW, but that does not need a high level of containment and isolation and, therefore, is suitable for disposal in near-surface, landfill-type facilities with limited regulatory control. Such landfill-type facilities may also contain other hazardous waste. Typical waste in this class includes soil and rubble with low levels of activity concentration. Concentrations of longer-lived radionuclides in VLLW are generally very limited.

waste, very short-lived (VSLW) Waste that can be stored for decay over a limited period of up to a few years and subsequently cleared from regulatory control according to arrangements approved by the regulatory body, for uncontrolled disposal, use or discharge. This class includes waste containing primarily radionuclides with very short half-lives often used for research and medical purposes.

waste characterisation Determination of the physical, chemical and radiological properties of the waste to establish the need for further adjustment, treatment or conditioning, or its suitability for further handling, processing, storage or disposal.

waste conditioning Those operations that produce a waste package suitable for handling, transport, storage and/or disposal. Conditioning may include the conversion of the waste to a solid waste form, enclosure of the waste in containers and, if necessary, provision of an overpack.

waste container	(See: *container, waste*)
waste disposal	(See: *disposal*)
waste management, radioactive	All administrative and operational activities involved in the handling, pre-treatment, treatment, conditioning, transport, storage and disposal of radioactive waste.
waste package	(See: *package, waste*)
waste processing	(See: *processing, waste*)
waste treatment	Operations intended to benefit safety and/or economy by changing the characteristics of the waste. Three basic treatment objectives are: a) volume reduction; b) removal of radionuclides from the waste; and c) change of composition.

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International Structure for Decommissioning Costing (ISDC) of Nuclear Installations

Cost estimation for the decommissioning of nuclear facilities can vary considerably in format, content and practice both within and across countries. These differences may have legitimate reasons but make the process of reviewing estimates complicated and the estimates themselves difficult to defend. Hence, the joint initiative of the OECD Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA) and the European Commission (EC) was undertaken to propose a standard itemisation of decommissioning costs either directly for the production of cost estimates or for mapping estimates onto a standard, common structure for purposes of comparison. This report updates the earlier itemisation published in 1999 and takes into account experience accumulated thus far. The revised cost itemisation structure has sought to ensure that all costs within the planned scope of a decommissioning project may be reflected. The report also provides general guidance on developing a decommissioning cost estimate, including detailed advice on using the structure.

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