

A Standardised Listing of Cost Items for Decommissioning Costing – 11483

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ABSTRACT

The paper presents an overview of recent work undertaken jointly by the European Commission, the OECD Nuclear Energy Agency and the International Atomic Energy Agency to update the standardised list of cost items for decommissioning costing, which they first published in 1999 (colloquially known as the “Yellow Book”). The overall objective of this initiative has been to provide a harmonised basis for presenting cost estimates, so that the basis for the cost amounts can be better understood and compared, taking into account the assumptions, boundary conditions and input data used for costing. The first standardised structure of items for decommissioning costing was issued in 1999 [1]. Since then, experience with using this structure was accumulated which serves as the background for updating of this standardised structure. The paper provides an outline of the hierarchical numbering system for the ‘standard’ decommissioning activities, including a description of the main ‘high level’ activities and cost types. Managing the relationship between the project work breakdown system and the standardised cost structure is discussed. Finally, an overview of the ‘Users’ Manual’ for facilitating the use of standardised cost structure is given.

Acknowledgement: The participation of Vladimir Daniska was supported by the Slovak Research and Development Agency through the grant No. APVV-0761-07 and partially by the Ministry of Education of the Slovak Republic, decree No. CD-2009-36909/39460-1:11.

INTRODUCTION

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 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 period of operation of the facility the cost estimate provides the basis for the detailed planning of the dismantling and site cleanup 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 timeframe 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 a document 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 Nuclear Energy Agency (NEA), the International Atomic Energy Agency (IAEA) and the European Commission [1]. 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 first step, an evaluation of users’ experience with the original version. The outcome of this suggested that the updated document 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 a Users' Manual to promote uniformity in the use of the revised cost structure.

The revision of the Yellow Book was organised as a 2-year period taking place during 2009-2010; overall project coordination was done by the Decommissioning Cost Estimation Group (DCEG) of the NEA, in which IAEA and the European Commission (Directorate General for Energy) are also participants. The revised document will be published jointly by the three sponsoring organisations during 2011.

THE STANDARDISED LISTING OF COST ITEMS FOR DECOMMISSIONING (“YELLOW BOOK”)

The objectives of the revised Yellow Book are:

- 1) to present an updated version of the standardised cost structure first published in 1999;
- 2) to provide an associated Users' Manual which gives general guidance on developing a cost estimate for decommissioning a nuclear facility and, in particular, on using the standardised cost structure.

It comprises three main parts, the first of which 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. Part 2 presents the revised cost structure and Part 3 presents the associated Users' Manual.

Decommissioning activities are represented in a hierarchical structure containing three levels, with eleven Level 1 activities being defined broadly according to the type of work activity, e.g. dismantling, waste management etc., as shown below.

Level 1 Activities:

- | | |
|----|--|
| 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 and demolition and site restoration |
| 08 | Project management, engineering and support |
| 09 | Research and development |
| 10 | Fuel and nuclear material |
| 11 | Other costs |

Level 2 activities represent a sub-division of the Level 1 activities, e.g. dismantling is divided according to major steps such as decontamination, dismantling of major systems etc. and waste management is divided according to different waste types, such as high level waste, intermediate level waste etc.

Level 3 activities provide a further sub-division of activities, e.g. decontamination is divided according to open systems, closed systems, buildings etc. Level 3 activities provide the most detailed (fundamental) representation of a decommissioning project provided in the Yellow Book cost structure, the corollary being that in order to convert estimates produced according to other cost structures a correspondence with the Level 3 activities first needs to be established by the cost estimator.

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.

Four cost groups are defined at each level at the original definitions in 1999 as:

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

It is assumed that the cost group structure is respected at each level of the Yellow Book hierarchy starting from the level of elementary decommissioning activities, through the upper hierarchical users' levels up to the level 3, level 2 and level 1.

Important drivers for the decision to update the Yellow Book, after ten years of use, included:

- redefinition and/or regrouping the items in order to follow more plausibly the sequence of decommissioning activities, main phases in decommissioning process and 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);
- implementing the latest IAEA (2009) classification of radioactive waste; reflecting the main types of activities related to waste management such characterisation, processing, storing, disposal and transports, and considering separately hazardous and conventional waste;
- defining unambiguously the content of items at the third hierarchical level of the cost structure;
- excluding items outside the scope of decommissioning projects, e.g. uncertainties outside the defined project scope such as changes to national policy;
- developing the users' manual to facilitate a common understanding of the use of the revised standardised listing.

CHARACTERISTICS OF REVISED CHAPTERS 01 TO 11 OF THE STANDARDISED LISTING

Chapter 01 “Pre-decommissioning actions” concerns the activities which are needed prior to licensing (approval) of a decommissioning project, including contracting activities, if the general contractor or multi contractor model is implemented. The activities are graded starting from the very preliminary costing feasibility studies (in some countries at commissioning of the facility) up the level of detailed decommissioning documentation for licensing and planning. Most of these activities are specific engineering, planning and managing activities, performed by the owner's personnel and by contracting at companies specialised for preparing the decommissioning documentation.

Chapter 02 “Facility shutdown activities” concerns the activities realised in the frame of the transition period after the shutdown until the licence for decommissioning is obtained [2]. Main purpose of these activities is to prepare the facility for decommissioning, using the experienced operation personnel and in specific cases, the specialised services. As the standard, at the start of decommissioning, there is no historical/legacy waste (including operational), the systems are without any operation fluids and the primary systems are decontaminated using the operational procedures (may be modified for harder decontamination) and personnel. This situation is hard to achieve in old facilities or facilities after accidents. In these cases, the assumptions and boundary conditions for a decommissioning project should define the starting position of the project in relation to the chapter 02.

The removal of all operational waste is included into the chapter; using existing operational procedures and personnel. Further treatment, conditioning, transports and disposal is included into the chapter 05. Retrieval of historical/legacy waste is in chapter 05.

Chapter 03 “Additional activities for safe enclosure and entombment” concerns the activities which are implemented in the decommissioning scenarios with deferred dismantling. These activities are needed for preparation of the safe enclosure for the facility in order to ensure the long term stability and safety during the period of safe enclosure. This chapter is not implemented in decommissioning scenarios with immediate dismantling. If

there is partial decommissioning of selected systems and buildings during the phase of preparation of safe enclosure, the activities are organised according chapters 04 to 11.

In the specific decommissioning scenarios of entombment, the chapter involve also the activities for achieving the final state of entombment. Other activities before achieving the final state are organised according chapter 04 to 11.

Chapter 04 “Dismantling activities within the controlled area” concerns the activities for removing the contaminated and activated systems and structures from the controlled area and identified contaminated items at the site outside of the controlled area. Prior to dismantling, there are procurement activities, preparation activities and pre-dismantling decontamination activities for ensuring the safe dismantling. Dismantling in the reorganised chapter is organised according the types of facilities and according to main components and materials to be removed. 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 chapter. At the end the final radioactivity survey of buildings is realised. The buildings are ready for conventional demolition (chapter 07), if this is part of the decommissioning strategy.

Chapter 05 “Waste processing, storage and disposal” concerns all the activities for management of historical/legacy waste and for decommissioning waste generated in activities of chapter 04 (primary and secondary waste) and conventional and hazardous waste generated in chapter 07. At the beginning of the chapter, there are activities for establishing, operational support and decommissioning of the waste management system operated within 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 chapter 02, if this is the case. Waste types not covered by the waste management system operated within the decommissioning project are considered as external services. Waste management systems shared with other decommissioning projects are also the options.

Management of waste in the reconstructed chapter 05 is organised at the second level according the types of waste as defined in the latest IAEA waste classification [3]. Characterisation of any kind, waste retrieval (where this occurs) and processing, final conditioning, storing, transports, disposal and containers for each type of waste are considered at the third level. The end state of all types of waste is the disposal at repositories for radioactive waste for relevant levels of waste, repositories for hazardous waste, repositories for conventional waste and free release or conditional release of reusable materials. Specific treatment activities (sorting, fragmentation, decontamination, supercompaction, incineration, conditioning, any characterisation methods, etc., are identified at the fourth levels; the extent and additional numbering is open for user.

Chapter 06 “Site infrastructure and operation” concerns the activities for site security and surveillance, site operation and maintenance, site upkeep, operation of support systems and radiation and environmental safety monitoring. All these are the activities for ensuring 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 getting lower as the decommissioning proceeds. Proper adjustment of these activities is important.

Chapter 07 “Conventional dismantling and demolition and site restoration” concerns 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 in chapter 04) and for buildings outside the controlled area according the scope of the decommissioning project. Some of the buildings can be refurbished for their further use or can be considered as the site assets of a decommissioning project. Activities include the site cleanup, landscaping and the final survey of the site. Management of conventional and hazardous waste from dismantling and demolition is included into chapter 05.

In some case the site is released with defined restrictions which require additional cost for the period of restricted use of the site or its parts. The activities in chapter 07, especially the conventional demolition can include costly items, so the clear definition of the end state of buildings and site is required in assumptions and boundary conditions for the decommissioning project. As an example the end state can differ in no demolition of buildings, demolition to the level of - 1m or complete demolition of concrete structures to the lowest levels.

Chapter 08 “Project management, engineering and support” concerns all types of activities for management of decommissioning activities, engineering, technical, safety and other relevant support, during all phases of the decommissioning project. Support activities prior to start of decommissioning activities 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 be differentiated between owner costs and contractor costs. The conditions for performing those activities can be different on the side of the owner and contractor, so these activities should be evaluated separately. Two identical segments, for licensee and contractors are available in reconstructed chapter.

Another specific aspect for activities is the grading of activities of the chapter 08 according to the phases of the decommissioning project and also within individual phases. The extent of activities of the chapter 08 may be very different so a clear representation of the relevant activities is important.

Chapter 09 “Research and development” concerns all activities with the character of research and development, specific for the decommissioning projects, where the information due to background of the project, is not sufficient or not available at actual time. Normally, research and development is contracted to specialised institutions and companies. Simulation of complicated work on model may be done by the personnel of the owner or as contracted cases at specialised institutions and companies.

Chapter 10 “Fuel and nuclear material” concerns the activities defined within the decommissioning project for spent fuel and for nuclear materials after defueling of reactors (chapter 2). The extent of activities may be uncomplicated for a NPP after a standard shutdown – the spent fuel is transported from the cooling system in the reactor building into the external storage facility for long term storing of the spent fuel where another story of the spent fuel starts. It is supposed the long term spent fuel store is available. Decommissioning of large spent fuel storage facilities, such as the stores for nuclear power plants, is organised as a separate decommissioning project. Situation may be different for NPP’s or research reactors where the external storage facility is not available due to type of the spent fuel, due to damage of 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. Special programmes for repatriation of high enriched fuel for research reactors may be another example. Non trivial cases may be identified also for fuel cycle facilities and for other experimental facilities.

Chapter 11 “Other costs” concerns cost items which are directly related to a decommissioning project (are within the scope of the project) but cannot be allocated to any of the above discussed chapters 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 which leave the nuclear facility to be decommissioned, payments to authorities and various specific external services or payments with no direct allocation to chapters 01 to 10. Taxes and insurances are addressed in this chapter. In some decommissioning projects, assets may be identified in relation to the sale of reusable equipment or materials as the result of the activities in the chapter 02, chapter 04 or chapter 07. Reuse of the site may play an important role in some cases. All assets during the decommissioning project are represented in chapter 11.

PRESENTATION PLATFORM FOR THE STANDARDISED LISTING OF COSTS

One of the main drivers for issuing the original Yellow Book was the harmonisation of the reporting of decommissioning costs, with better definition of the content of the individual items and of different cost types. The presentation format is based on a matrix which presents the numbered items of the standardised listing at the first, second and third hierarchical level in successive rows of the matrix and the cost groups in different columns. The main structure of the matrix is presented in Table I. the complete version involves all items on the third level, e.g. as shown in Table I for item 01 at the first level and for items 01.0100 and 02.0200 at the second level and items 01.0101 to 01.0103 and 01.0201 to 01.0203 at the third level. Reporting matrices for decommissioning projects may involve also the levels additional to the third level.

Table I. Structure of the presentation platform for the standardised listing of costs

Level 1	Level 2	Level 3	Name of SL item	Labour cost	Investment	Expenses	Contingency	Total cost	User defined data extensions				
01			Pre-decommissioning actions										
	01.0100		Decommissioning planning										
		01.0101	Strategic studies										
		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													

The cost data are introduced into the matrix at the third level, the data at the second and first numbered level and total cost data for a decommissioning project are aggregated data from lower levels. Users may extend the matrix by adding additional columns which involves other data such as manpower, exposure, waste data, etc. The total cost at each level is the sum of four basic cost groups.

In this way, the matrix represents a general harmonised platform for presenting the decommissioning cost. The matrix may be also the base for additional processing of cost data such as risk assessment and other methods.

METHODS OF USE OF THE STANDARDISED LISTING

Decommissioning process is represented by set of discrete elementary decommissioning activities for which the resources are identified such as volume of materials to be dismantled, personnel involved in the activity, duration of the activity, conditions for performing of the activity and other parameters. The same decommissioning activities may be repeated many times within a decommissioning project with various resources. Typical decommissioning activities may be identified and the purpose of the standardised listing is to develop the systematic structure of these typical activities.

Decommissioning costing, as it is identified in current costing methodologies [4, 5, 6] is the process which is related to individual elementary decommissioning activities. The purpose of decommissioning costing is to evaluate cost and other decommissioning parameters for individual discrete decommissioning activities, for groups of decommissioning activities and phases, and cost for entire decommissioning project.

Elementary decommissioning activities of a decommissioning project, as the base for decommissioning costing, may be organised according various structures. The traditional approach is based on the work breakdown structure of the decommissioning project (“WBS”) which organises the decommissioning tasks according real sequence of work packages for performing the decommissioning project. The work packages are organised in a hierarchical structure to form the decommissioning schedule for which the planning and managing methods may be applied. Costing may be applied for individual decommissioning tasks structured according the work breakdown structure. The resulting costs are presented according to the work breakdown structure of the decommissioning project.

Another approach for organising of the discrete decommissioning tasks of a decommissioning project for the purpose of costing is to organise the defined activities according the standardised listing which is broken down into levels lower to the third numbered level, i.e. the project work breakdown system is aligned directly with the standardised cost structure. The breakdown may be organised according to different phases of the decommissioning project, the hierarchical structure of the facility inventory database (such as buildings, floors, rooms and equipments), technological systems, elements of organisational structure, etc. In this case, the costing is linked to this detailed breakdown of the standardised listing cost structure. The resulting costs are then structured, by aggregation, according to the standardised listing cost structure.

The principles for implementing both basic approaches for implementing the standardised listing (SL) into decommissioning costing are presented in the Fig. 1. This figure presents main relations between the generic standardised listing structure as it is defined, cost calculation structures, work breakdown structure of a decommissioning projects and Gantt chart as the representation of the work breakdown structure in planning and managing systems.

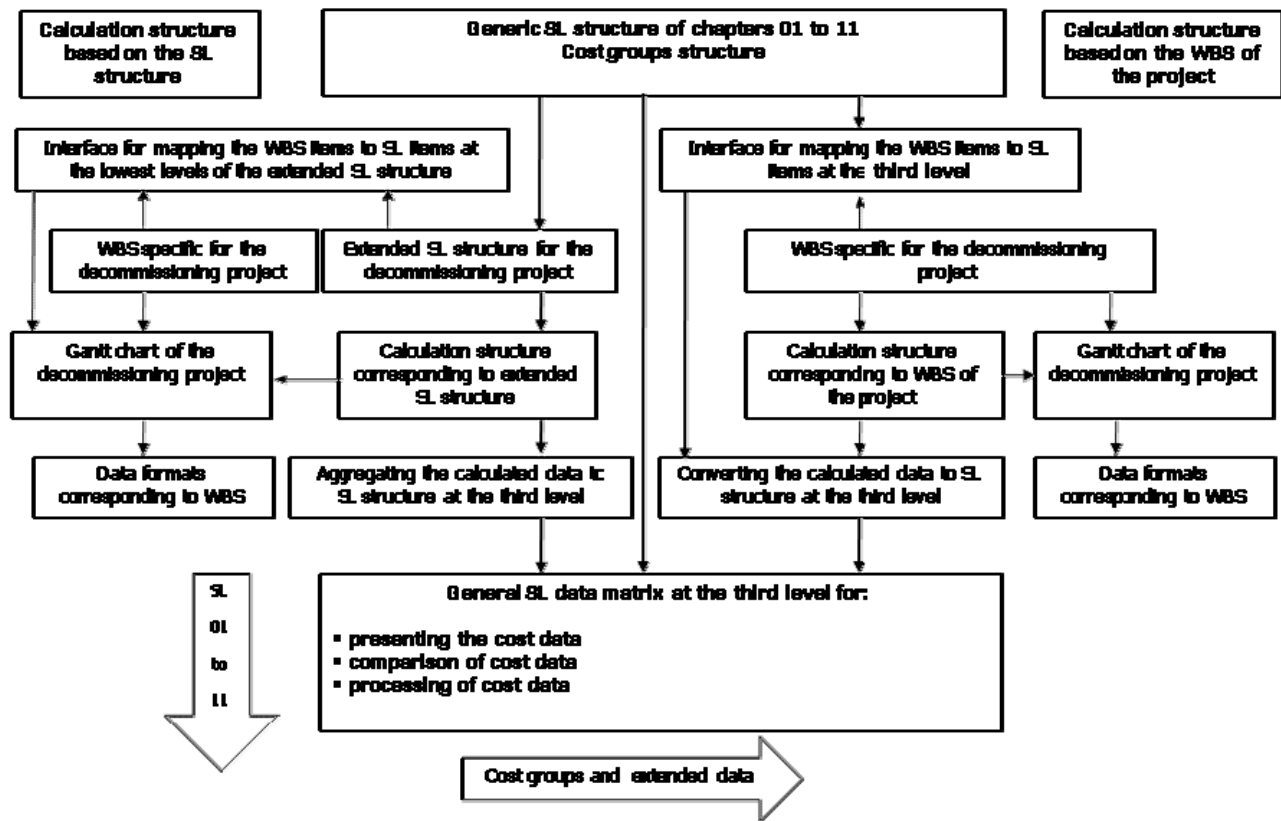


Fig. 1. Two basic approaches for implementing of standardised listing into decommissioning costing.

The first approach for implementing the standardised listing into costing is based on mapping of the items of the work breakdown structure items at the lowest levels to the items of the standardised listing items at the third level. Principle of this mapping is presented in the Fig. 2. The core of the mapping is the interface (table) which links the work breakdown structure items to standardised listing items.

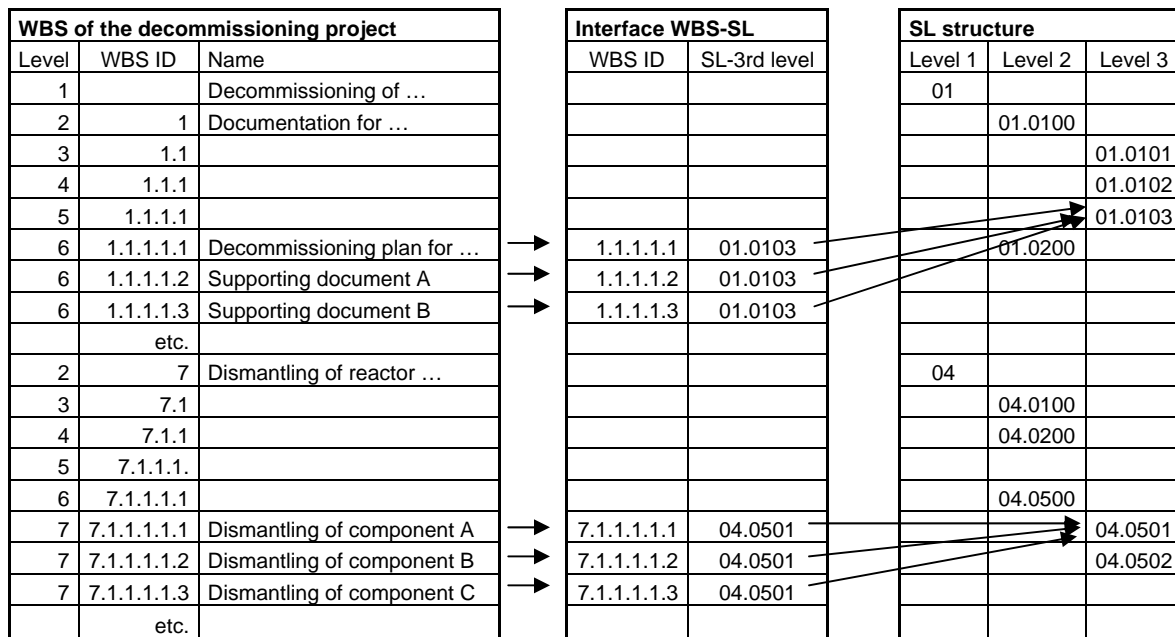


Fig. 2. Linkage of the work breakdown structure items to standardised listing items at third level.

The second approach involves the use of the standardised listing as the cost calculation structure which is in principle the generic standardised listing structure extended to levels lower than the level 3 of the standardised listing. Using the extended standardised listing as the cost calculation structure, guarantees that the cost calculated at each elementary activity are allocated unambiguously to relevant items of the standardised listing at the third level, which is the lowest level of the standardised listing matrix for presenting the cost data. In this case, an inverse interface is needed to convert the data calculated in cost calculation structure based on the standardised listing to the items of the work breakdown structure of the decommissioning project, i.e. the approach is the inverse of that presented in Fig. 2. Implementing of the standardised listing as the base for cost calculation structure may have some advantages in harmonisation in decommissioning costing. Common standardised calculation platform may be established which is harmonised to the third numbered level for any calculation case and aspects which are specific for a types of nuclear facilities, such as pressurised reactor, boiling reactors, graphite reactors, various research reactors and other facilities, may be harmonised at the lower calculation levels.

USERS' MANUAL

The Users' Manual was developed for facilitating the use of standardised listing. It comprises six chapters [7]:

- Methodology of cost estimation – providing detailed information on how is the standardised listing organised, what is the meaning of individual items at the Level 1, Level 2 and Level3, what is the meaning of cost groups which are presented at each level; presentation of the standardised listing as the harmonised platform for decommissioning costing; general background for using the standardised listing and two main approaches for using the standardised listing in decommissioning costing which were identified during last ten years of using the standardised listing and a short review of methodology for decommissioning cost calculation as the identified actual best practice in costing;

- Guidance for quality assurance and traceability of data – providing recommendation on how to handle with data in accordance with QA;
- Guidance for application of contingency – providing guidance on the inclusion of contingency provisions within decommissioning cost estimates;
- Guidance for risk management and uncertainty – providing guidance on how the proposed cost structure may be used a basis for undertaking an analysis of the levels of risk and uncertainty associated with a particular estimate ;
- Guidance for cost estimation reporting formats – providing guidance on how cost estimates may be reported;
- Development a list of assumptions and boundary conditions - deals with assumptions and boundary conditions under which the considerations and recommendations mentioned in above chapters were done.

CONCLUSIONS

The sponsoring organisations consider that greater standardisation of the format and content of decommissioning cost estimates will give greater transparency to the decommissioning process and will help build regulator and stakeholder confidence in the adequacy of funding provisions.

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