Lessons learned from implementation of International Structure for Decommissioning Costing (ISDC) of Nuclear Installations – 17198

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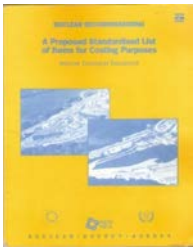
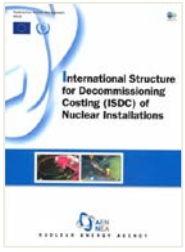
ABSTRACT

The paper presents the experience accumulated at the company DECOM in Slovakia in implementation of the "International Structure for Decommissioning Costing (ISDC) of Nuclear Installations" [1] in cost estimation for decommissioning projects. The ISDC was issues in 2012 by main international organisation involved in decommissioning - OECD/NEA, IAEA and European Commission. The primary purpose of the ISDC, as highlighted by the issuing organisation, is to promote the transparency and understanding of cost for decommissioning projects by presenting the cost using the standardised ISDC cost format. General experience shows that the ISDC seems to be the only cost structure which is able to present cost for any decommissioning project after converting the cost into the ISDC cost format. The company DECOM started to implement the ISDC already in 1999 by implementing the predecessor of the ISDC known as "Yellow Book" which was issues in 1999 by the same international organisations; later by implementing the ISDC. Experience of DECOM by implementing the Yellow Book was used also in developing the ISDC. Experience of DECOM relates to the use of the ISDC as the base for cost estimation structures, developing the ISDC-based cost estimations codes and to transformation of cost for decommissioning projects for benchmarking purposes. The ISDC approach to decommissioning cost estimation for research reactors was implemented also by the IAEA; the experience accumulated at DECOM was used to a great extent. The paper presents the DECOM experience mainly in developing the ISDC-based cost estimation structures used in ISDC costing codes and in ISDC benchmarking of cost for decommissioning projects.





INTRODUCTION, THE ISDC

The ISDC [1] is the result of the long term effort started in middle of 80-ties for development of a standardised cost structure for harmonisation in presenting and understanding the cost for decommissioning projects. The ISDC itself is the matrix of typical decommissioning activities which can be identified in any decommissioning project. Three numbered hierarchical levels were defined and four cost categories - labour cost, investment cost, expenses and contingency which are to be presented for each element of the ISDC. Principle structure is presented in the Figure 1. ISDC Level 1 includes Principal Activities which follow the principal phases of a decommissioning project, Level 2 means Activity Groups, i.e. groups of

decommissioning activities with similar nature and the ISDC Level 3 means the typical decommissioning activities.

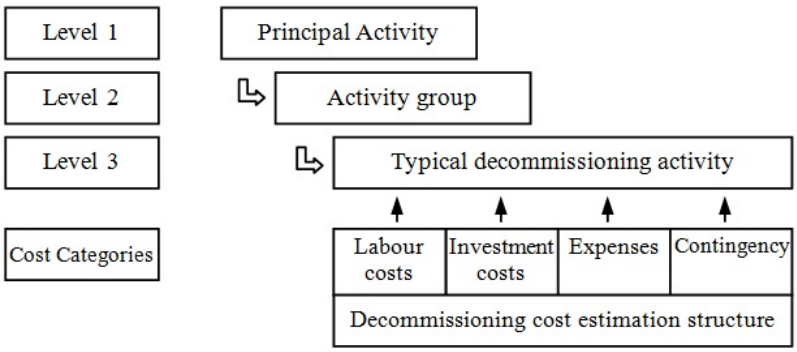


Fig.1. Matrix structure of the ISDC and ISDC cost categories

Example of headings of ISDC items in three hierarchical levels is following:

04 Dismantling activities within the controlled area

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)
- etc. (13 items in total at this level)

There are several principal issues which characterise the purpose of the ISDC:

- ISDC is the driver for harmonisation of presentation of cost for decommissioning projects; there are many national specific cost structures mutually incompatible.
- ISDC is the decommissioning projects oriented structure; ISDC represents all typical decommissioning activities which can be identified for any decommissioning project.
- Generic definitions of ISDC items facilitates understanding of individual cost items, i.e. what is behind the individual cost items.
- Proper understanding of decommissioning cost items is the key issue in comparison of cost for various decommissioning projects.
- Comparing using the same format may facilitate defending for own decommissioning project.
- ISDC supports all stakeholders involved in decommissioning due to transparency.
- Assumptions and boundary conditions for a decommissioning project presented in the ISDC format facilitate the understanding of individual ISDC cost items.

Content of ISDC items at the ISDC Level 1, the Principal Activities is following:

01 Pre-decommissioning actions - activities prior to issuing the decommissioning license, planning, characterisation, safety assessments, EIA, licensing activities;

02 Facility shutdown activities - preparation of the facility to decommissioning; at the end no fuel, no operational waste, systems empty, primary system decontaminated;

03 Additional activities for safe enclosure or entombment - preparation of the

facility to long term dormancy period and/or the entombment of remaining structures;

04 Dismantling activities within the controlled area - removal of radioactivity by decontamination and dismantling from systems, structures and site, buildings with controlled areas are cleared, management of generated waste is in ISDC 05;

05 Waste processing, storage and disposal - preparation, operation, decommissioning of waste management system; processing (including disposal) of radioactive waste from ISDC 04; processing of historical/operational waste (separate ISDC segment); processing of non-radioactive waste from ISDC 07;

06 Site infrastructure and operation - any site supporting activities, security, maintenance, operation of auxiliary systems, radiation protection

07 Conventional dismantling, demolition and site restoration - dismantling out of controlled area, demolition of all buildings, site restoration activities, management of generated waste is in ISDC 05;

08 Project management, engineering and support - mobilisation/demobilisation of the decommissioning project, project management, engineering support, health safety; separate ISDC segments for licensee and for contractors;

09 Research and development - R&D activities involved into decommissioning project;

10 Fuel and nuclear material - transport of spent fuel to interim storage, management of spent fuel is included only for research reactors; long term storage of spent fuel for NPP's is out of the ISDC (should be presented out of ISDC);

11 Miscellaneous expenditures - any of cost items and/or activities included into the decommissioning project but which cannot be included into ISDC 01 to 10; taxes, insurances, assets from project;

Principal Activities were presented for the first time in WM conferences in [2]. Typical distribution of ISDC Principal Activities for the immediate dismantling is presented in the Figure 2. The distribution has several phases for deferred option [1].

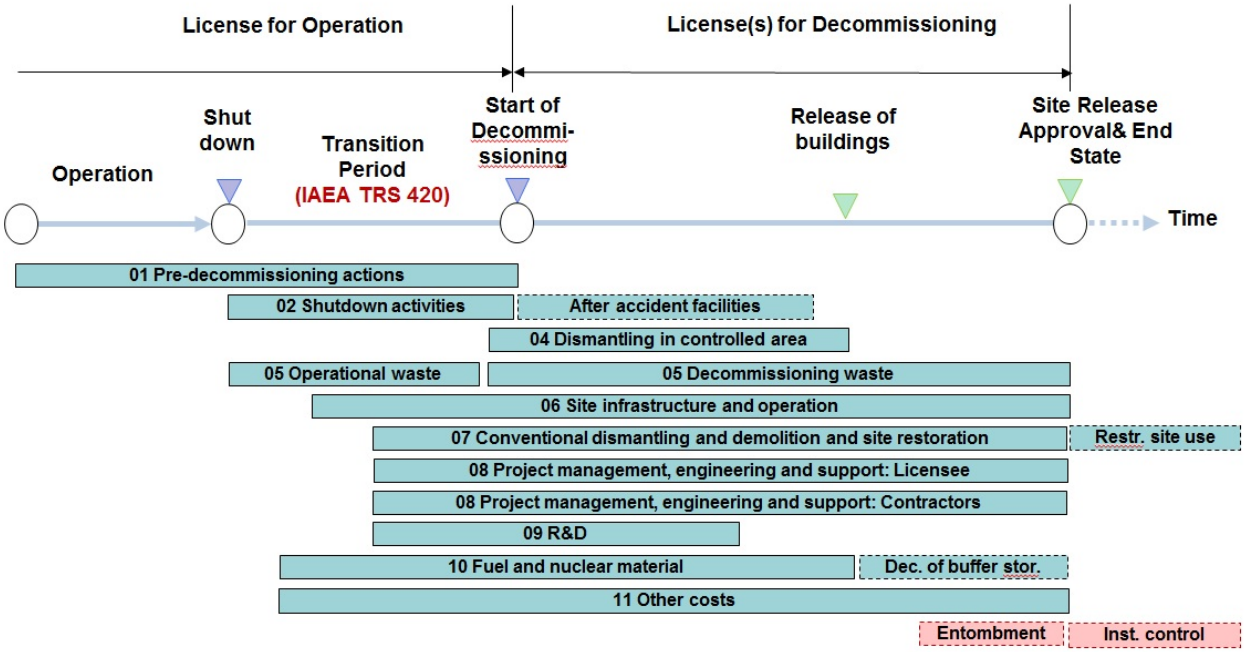


Fig.2. Distribution of ISDC Principal Activities in the immediate dismantling project [1]

Use of the ISDC for presenting the cost for decommissioning project has increasing tendency especially in Europe, extending its use worldwide is desirable. There is more than 15 years of experience in implementation of the Yellow Book and later the ISDC into cost estimation at the company DECOM. Most important experiences is the use of the ISDC as the base for cost estimation structures, ISDC based waste management systems and ISDC benchmarking of costs for decommissioning projects.

IMPLEMENTATION OF THE ISDC AS THE BASE FOR COST ESTIMATION STRUCTURES

A cost estimation structure should include all decommissioning activities and/or cost items which are relevant for the decommissioning project under evaluation. Most used approach for development of a cost estimation structure is the use of the work breakdown structure (WBS) of the decommissioning project as the basic frame which is extended by elementary calculation items as levels below the lowest levels of the WBS. Several lower hierarchical levels may be implemented. This approach was developed prior to development of the ISDC. When presenting the cost estimated in WBS based cost estimation structure, the items at the lowest level should be mapped to the ISDC items at the ISDC Level 3 [2].

Alternative approach developed at the company DECOM means that the cost estimation structure is developed as extensions below the three-level generic definition of the ISDC. The principle of extension for cost estimation purposes is presented in the Figure 3. In this approach, the presentation of cost in the ISDC format is straightforward, just as aggregation of cost data at upper levels; this aggregation at higher levels is the inherent feature of the ISDC. The linking of cost data from the lowest levels of the ISDC cost estimation structure to lowest levels of the WBS items is needed [2].

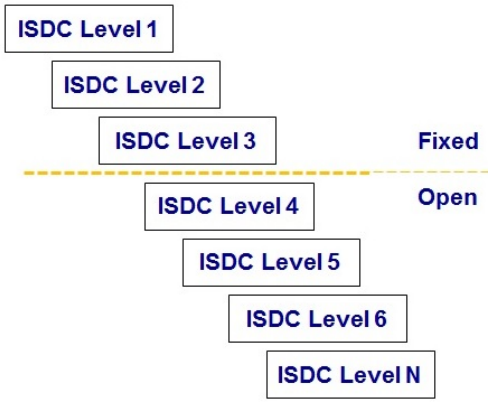


Fig.3. Extension of the ISDC

Examples of extension of the ISDC to lower levels are:

- Phases of the decommissioning project;
- Dismantling of systems and structures according to the facility inventory database; the cost estimation structure is developed as hierarchical structure building object - floor - room - inventory item;
- Specific ISDC segments for dismantling options for reactors and/or large primary components corresponding to the dismantling sequence and to the structure of inventory database;
- Segments specific for individual ISDC items lower to level 3;
- Waste management techniques lower to ISDC level 3 according to the specific system for simulation of material/radioactivity flow in

decommissioning developed at DECOM.

System of additional ISDC numbering of items lower to level 3 was developed in combination to the content of inventory database. Principal structure of the database is building object - floor - room - inventory item. Several ISDC templates were developed which are used for automatic generation of working versions of cost estimation structures. The generation is based on adding of items of cost estimation structure to the items of selected ISDC template (static calculation tree); the added part of the cost estimation tree (dynamical calculation tree) corresponds to the content of the inventory database. Combination of the ISDC templates and the inventory database proved to be very effective for generation of large cost estimations trees having tens of thousands of elementary cost estimation items.

Default cost estimation input data and cost estimation procedures are allocated automatically to individual elementary items of the dynamical parts of the cost estimation tree during the generation where relevant. System of classification of inventory database items (decommissioning categories) was developed [3] along with the relevant unit factors, which enables effective allocation of default data to individual elementary cost estimation items. After generation, the dynamical parts of cost estimation structure are ready for first runs, for optimisation of input data and subsequently for final calculation. Users may edit the default data as needed during the optimisation of the cost estimation options. Example of a segment of a generated cost estimation structure is presented in the Figure 4.

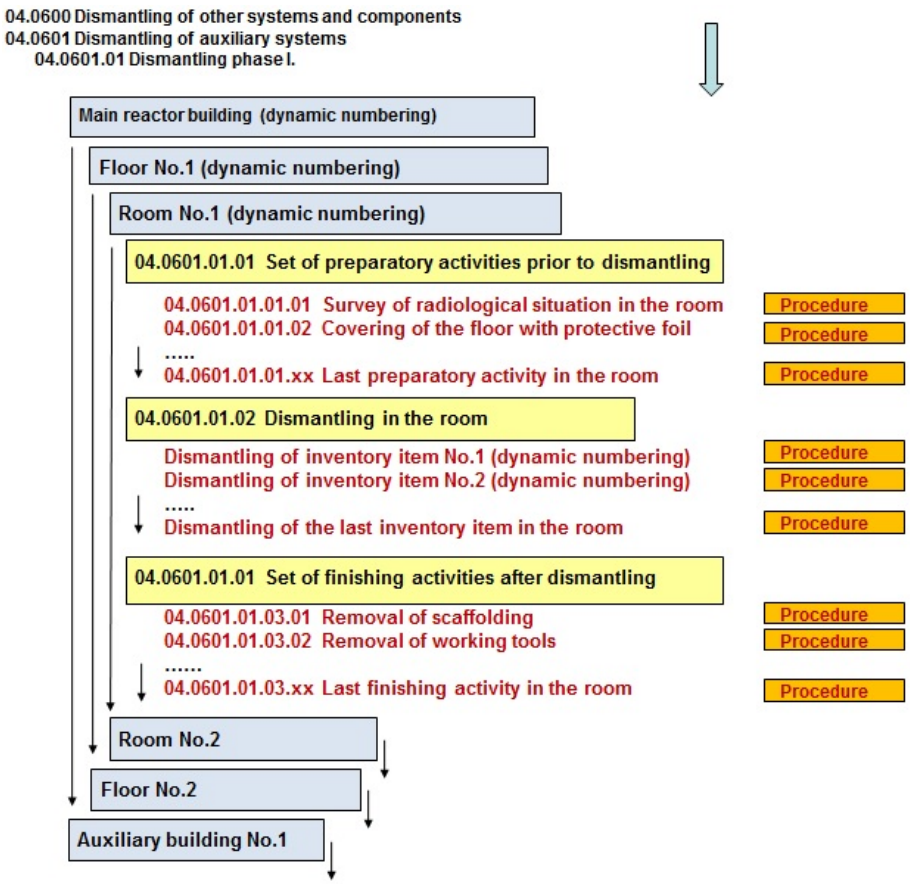


Fig.4. Example of a detailed automatically generated segment of a cost estimation structure corresponding to the structure of the facility inventory database

As presented above, one of the results of cost estimation for a decommissioning project is the project WBS in the form of a Gantt chart with resources data allocated to lowest levels of the WBS. The system was developed for automatic generation of the Gantt chart which has again two similar parts - user defined static WBS tree and dynamical parts generated according to the structure of the inventory database. The user can select the level of depth of dynamical parts prior to its generation, i.e. to the level of building objects, floor or room. At the lowest levels of the cost estimation tree, the user defines the ID's of the items of WBS at the lowest levels. Based on this, the system allocates the cost data and other project management data (workforce, staffs as examples) from the cost estimation structure to the items of the WBS; one-to-one allocation or aggregating of data with the same WBS ID's are possible.

ISDC-BASED CONCEPT FOR ESTIMATION OF WASTE MANAGEMENT COST

Estimation of cost for waste management (WM) activities requires first to estimate the quantities of individual types of waste which will be processed in individual waste management techniques including the disposal and/or release of materials as the final steps in waste management. As the "costing pools" are considered the individual waste management techniques for which the unit factors are defined and quantities should be estimated.

The ISDC implements the IAEA waste classification [4] which is defined at the ISDC

Level 2 of the Principal Activity ISDC 05. Groups of WM techniques are defined at the ISDC 05 Level 3, as an example characterisation, treatment, packaging, conditioning, etc. Selection of individual WM techniques used in a decommissioning project is below the ISDC 05 Level 3; the selection is open for ISDC users. There are two separate identical segments in the ISDC 05 - one for historical/legacy radioactive waste and one for decommissioning waste generated during the decommissioning projects. Non-radioactive waste from decommissioning is considered in the separate ISDC 05 item at the Level 2.

Estimation of quantities of individual types of waste can be done in various ways. Most used approaches are based on estimation of quantities prior to estimation of cost for WM, based on data in the facility inventory database - masses, volumes, materials, radiological parameters (nuclide compositions, levels of contamination, activation, as the main radiological data). There are many approaches how to estimate the individual quantities of waste types; in the case of deferred dismantling, the decay should be considered.

The system developed at DECOM for estimation of cost for WM in a decommissioning project follows exactly the ISDC 05 structure. Estimation of quantities of individual waste types is dynamical, i.e. quantities are estimated during the cost estimation process. This approach enables flexibility in definition and optimisation of WM system. Users may define the conditions for estimation such as the acceptance limits for disposal facilities, clearance levels, acceptance limits for individual WM techniques (if are defined). The decay of individual radionuclides is considered. Effect of pre-dismantling decontamination is considered.

In order to be able to use effectively this system, the inventory database should include the relevant radiological data. The concept of nuclide vectors (i.e. composition of individual radionuclides) is implemented which requires definition of nuclide vectors for contamination of inner and outer surfaces and for activation of individual items in the inventory database. Relevant dates are required - dates of definition of nuclide vectors, dates of definition of numerical values of radiological parameters (contaminations and activation) and the dates of performing the decommissioning activities.

The system is based on virtual mathematical partitioning of individual inventory items to elementary one-material components; these components are then included into the WM scenarios. The scenarios are based on the WM defined for a decommissioning project. The system of mathematical sorting of one-material components (based on nuclide resolved acceptance limits and clearance limits) simulates the real flow of materials and related radioactivity in WM for the decommissioning project. Principles of the WM system are presented in the Figure 5. The streams presented in the figure are composed from sequences of individual WM techniques.

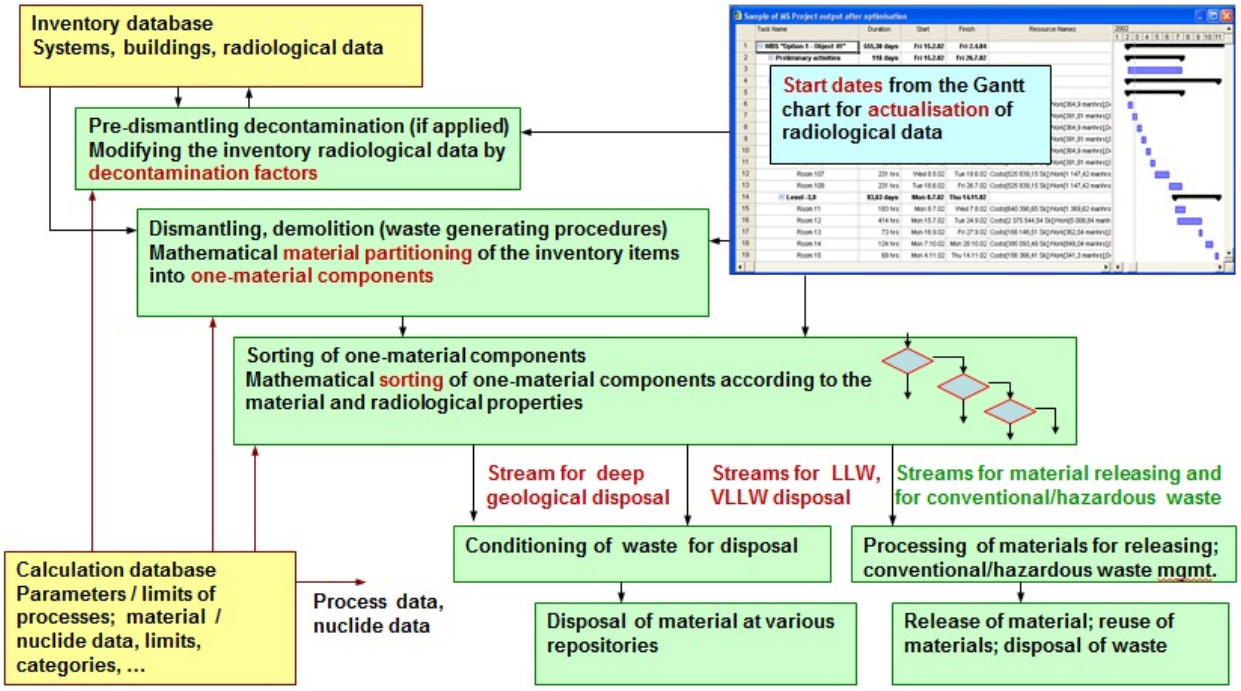


Fig.5. Principles of the WM system for simulating the flow of materials/radioactivity

The system proved to be very effective in optimisation of WM system for a decommissioning project and for the sensitivity analysis; as examples, by varying the nuclide vectors, levels of contaminations, deferring dismantling, acceptance limits and clearance limits.

ISDC BENCHMARKING OF COSTS FOR DECOMMISSIONING PROJECTS

Benchmarking of cost for various decommissioning projects can be done effectively only when the same cost format is used. The ISDC offers this general format. Experience of DECOM shows that it is possible to convert the cost data from any cost format to the ISDC format. The inevitable prerequisite for this is to understand the content of individual cost items involved in the cost format to be converted to the ISDC. Based on the knowledge of individual items, the conversion can be done in principle in two ways:

- One-to-one allocation of items from the converted format to items of ISDC when the contents of items match together fully;
- Splitting the items of the converted format to more ISDC items when the content corresponds to more identified ISDC items; conversion matrixes specific for individual items of the converted format should be developed.

In preliminary conversions, the total cost for individual items of the converted format is considered. If the contingency is known in converted formats, it is transferred to the ISDC contingency. In more detailed conversions, when relevant data are available, the conversion may do down to the level of individual ISDC cost categories.

Several conversion matrixes were developed at DECOM for published cost formats in decommissioning projects in Europe and in North America. Example of the cost for decommissioning projects is presented in the Figure 6; this example was presented at the WM conference in 2013 [5]. Assumptions and boundary conditions for the converted format plays important role in understanding the converted ISDC format.

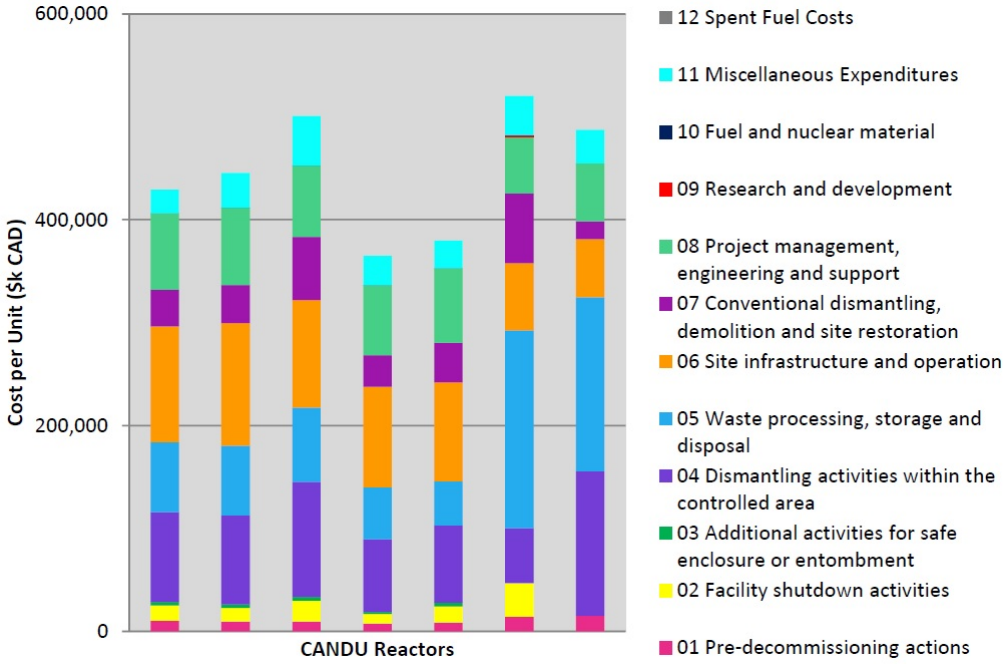


Fig.6.Example of converting the cost data for CANDU reactors to the ISDC format [5]

CONCLUSION

The ISDC proved to be effective tool for harmonised presentation of cost for decommissioning projects. When the presentation of cost in the ISDC format is supported by detailed assumptions and boundary conditions (corresponding to the ISDC format) for a decommissioning project, clear understanding of individual cost items may be achieved.

Except of this main purpose, the ISDC as the structure of typical decommissioning activities which can be identified in any decommissioning project (as for size, structure and radiological situation of the facility to be decommissioned), the ISDC can be effectively used as the base for cost estimation structures. This concept may extend the harmonisation in decommissioning cost estimation. Standard segments for cost estimation may be developed considering various types of reactors.

The experience of DECOM shows that the ISDC based cost estimation structures can be developed effectively and can be generated automatically in detail structure

and large extent by the costing code. This approach is supported by the facility inventory database for which the specific structure of physical and radiological parameters was developed. In parallel to cost estimation structure, the WBS of the decommissioning project can be developed which is further used for generation of the detailed Gantt charts. Both structures are mutually linked.

The ISDC based concept for estimation of cost for waste management in the frame of a decommissioning project was developed at DECOM which is based on simulation of real flow of materials and related radioactivity during the decommissioning project. The concept proved to be effective in optimisation of waste management system for decommissioning projects and for sensitivity analysis.

Benchmarking concept based on the ISDC, developed at DECOM, can be used for any cost formats when relevant data needed for understanding the individual items of converted cost formats are available.

The ISDC based costing concept implements the international cost estimation best practice as for costing procedure itself [6], [7]. Specific feature of this approach is that the ISDC cost categories are calculated at the level of elementary items at the lowest levels of the cost estimation structures (the recommended “bottom up” approach [6]). New trends in decommissioning costing such as the probabilistic estimation of contingencies and evaluation of out-of-scope risks to decommissioning projects are in implementation.

The ISDC concept was recently extended by implementation of internet technologies which enable remote access to the costing code, enhance the user friendly features, and remote support by experts groups. In this way, the ISDC concept is extended to form a universal ISDC platform; more information is in parallel paper No. 17230 “Code eOMEGA - Decommissioning Costing of Nuclear Facilities Based on the ISDC”.

The ISDC based costing concept was taken over also in the IAEA for preliminary cost estimation for research reactors [8]. The ISDC costing code CERREX in Excel was developed and is in use in the frame of the IAEA project DACCORD. The experience in this project show that at the preliminary levels the ISDC can be effectively used for identification of decommissioning activities for a costing case, i.e. it may play the role of a decommissioning plan. The CERREX code implements the ISDC costing approach, the simplified inventory database and the simplified system for development of waste streams. Output data formats are at the ISDC Level 1, Level 2 and Level 3.

ACKNOWLEDGEMENTS

This work has been supported by the Slovak Research and Development Agency under the contract No. APVV-15-0558.

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