Code eOMEGA - Decommissioning Costing of Nuclear Facilities Based on the ISDC – 17230

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ABSTRACT

The paper is focused on the presentation of the development process, calculation procedure and main features of the eOMEGA code used for decommissioning costing of nuclear facilities. The methodology for decommissioning cost calculation implemented to the eOMEGA code is fully in line with the international recommendations, best practices and is completely based on the ISDC - The International Structure for Decommissioning Costing (ISDC) of Nuclear Installation. ISDC represents the standard and common platform for presenting the results of the cost estimates for decommissioning projects related to any type of nuclear facility. The main goal of the eOMEGA costing code is to provide the ISDC based flexible, open, modern and user-friendly tool for transparent and reliable decommissioning costing for any type of nuclear facility with any systems, structures and radiological situation at the end of the operational period. Moreover, the eOMEGA decommissioning costing code is intended to be one of the modules of the universal eOMEGA platform which should cover also the other activities within the back-end of nuclear power engineering e.g. decommissioning funding, back end of nuclear fuel cycle, site remediation.

INTRODUCTION

Reliable cost estimation is considered to be one of the most important elements of decommissioning planning. On the other hand, the appropriate and harmonised decommissioning costing structure and methodology should be applied as well as a proper costing tool for presenting a decommissioning costing data transparently and allowing to understand the differences in decommissioning costs and to compare the results for different decommissioning costing project.

The eOMEGA code is a logical follow-up of the DECOM long term involvement (more than two decades) in the field of decommissioning planning and costing including the development of unique decommissioning costing codes.
The basic idea behind the eOMEGA code development is to merge the advantages of two existing matured solutions (Fig.1):

- *OMEGA* - Decommissioning costing software with fully implemented ISDC structure, methodology and ISDC costing approach [1] with some unique features; respecting also the international requirements, trends and best practices in the decommissioning costing [2], [3]

- *ADIOS* - Web-based platform with tools and processes to implement any web-based software solution with user-friendly interface

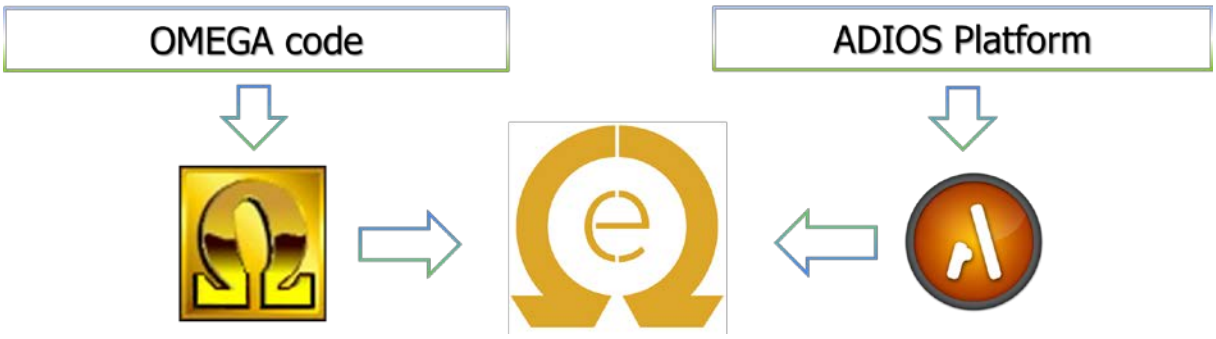

Fig.1. eOMEGA code – basic idea

INTERNATIONAL STRUCTURE FOR DECOMMISSIONING COSTING (ISDC) OF NUCLEAR INSTALLATIONS

The International Structure for Decommissioning Costing (ISDC) of Nuclear Installations was jointly issued in 2012 [1] by OECD Nuclear Energy Agency (NEA), International Atomic Energy Agency (IAEA) and European Commission (EC) to act as standard and common platform for presenting the cost estimates for decommissioning projects of any type of nuclear facility. The purpose of the ISDC is to:

- encourage common usage and facilitate the communication between cost estimators and involved stakeholders;
- promote uniformity in decommissioning costing;
- avoid inconsistency or contradiction in the results;
- be of worldwide interest to all stakeholder involved in decommissioning.

ISDC decommissioning activities are organised as a hierarchical structure with three numbered levels aggregating the data from the bottom to top i.e. 3rd level is the reference level and 1st and 2nd level are aggregating levels. Moreover, ISDC is opened down for any additional user's defined numbering down to 3rd level. The ISDC defines four cost categories to be allocated to each individual ISDC item: labour costs, investments (capital costs, costs for equipment), expenses and contingency (Fig.2).

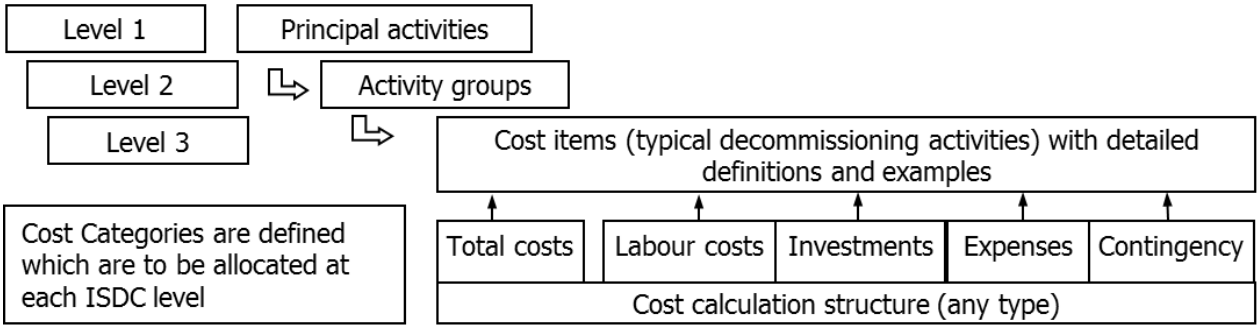

Fig.2. Hierarchical Structure of ISDC and ISDC cost categories

At Level 1, eleven Principal Activities are identified, representing the basic groups for splitting the decommissioning costs:

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
09 Research and development
10 Fuel and nuclear material
11 Miscellaneous expenditures

eOMEGA CODE – INTRODUCTION AND MAIN FEATURES

The development of eOMEGA was focused on the creation of decommissioning costing tool with following main features:

- fully implemented ISDC structure, costing methodology and costing approach following also the motivation that eOMEGA could also:
  - facilitate the harmonisation, transparency and benchmarking in the decommissioning costing;
  - contribute to promoting, extending or future upgrading of the ISDC.
- meet the actual international requirements, trends and best practices in the decommissioning costing [2], [3];
- applicable for any type of nuclear facility (nuclear power plant, research reactor, waste management facility, etc.) with any composition of buildings, technological systems, structures and radiological situation at the end of the operational period (including the end of facility operation after accident);
- applicable in any phase of the decommissioning planning process starting from very preliminary phase during construction of the facility up to final planning just before the start of decommissioning or during transition period;

- high level of customization of costing cases by reflecting specific facility conditions, infrastructure, national legislative or technical framework - user should have the costing case fully in “own hands”;
- available to any stakeholder involved in the decommissioning planning to facilitate the building of confidence in the decommissioning cost estimates and understanding the cost elements;
- flexible, open, transparent, modern and user-friendly environment;
- accessibility via internet and supported by secure internet technologies with possible expert support and maintenance to be performed remotely;
- no special software is required; only internet browser and standardly used office applications are needed; but links to the other professional software (e.g. MS Project, Primavera) are possible.

eOMEGA CODE – CALCULATION PROCEDURE

The procedure for calculation of costs and other decommissioning parameters (workforce, exposure, waste quantities) in eOMEGA consists of following steps:

A. Development of input inventory database

Inventory database of the nuclear facility (Fig. 3) is considered to be a key input for the calculation of decommissioning costs for the activities such as decontamination, dismantling or demolition (inventory dependent activities). The development of inventory for each nuclear facility in the eOMEGA code should be divided into two main steps:

- Development of the structure of the nuclear facility (site) to be decommissioned: nuclear facility – buildings – floors – rooms – technological equipment and civil structures components;
- Definition of the relevant database parameters (data) for database items:
    - Physical data e.g. mass, surface, volume, room dimensions;
    - Radiological data e.g. surface contamination, induced activity, dose rates, relevant nuclide vectors;
    - Calculation data e.g. decontamination, dismantling and demolition category of equipment

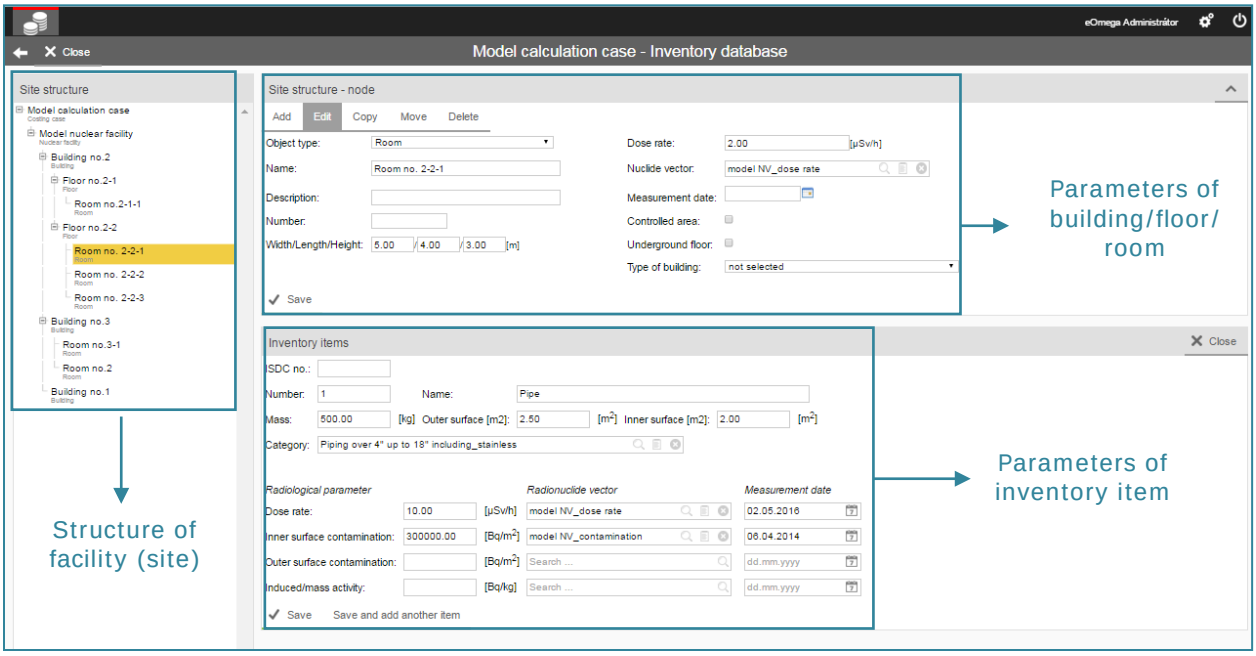

Fig.3. Definition of inventory database in eOMEGA

B. Definition of input data

Except of the inventory, the following set of input data needs to be defined for the successful run of the costing case in eOMEGA:

- General calculation data e.g. labour rates, radiological limits for release of materials to environment, waste acceptance criteria;
- Unit factors (workforce, expenses and investments unit factor) for decontamination, dismantling and demolition as well as for waste management calculation procedures;
- Technological data e.g. capacities of technologies for waste management, radioactivity distribution coefficients, composition of the working groups

The predefined input parameters or templates are included in the eOMEGA and they can be modified by the user respecting the specific features or requirements of each calculation case.

C. Definition of ISDC costing case

The definition of the individual costing case is based on the development of ISDC case specific calculation tree (Fig. 4). The previously defined inventory database (facility (site) structure) is linked to the relevant ISDC item. Set of pre-defined parameters specific for each calculation node (ISDC item) should be modified by the user – especially for the period dependent activities (e.g. preparation or management of the project, site security, maintenance) and for collateral costs (taxes, fees, other one-off payments).

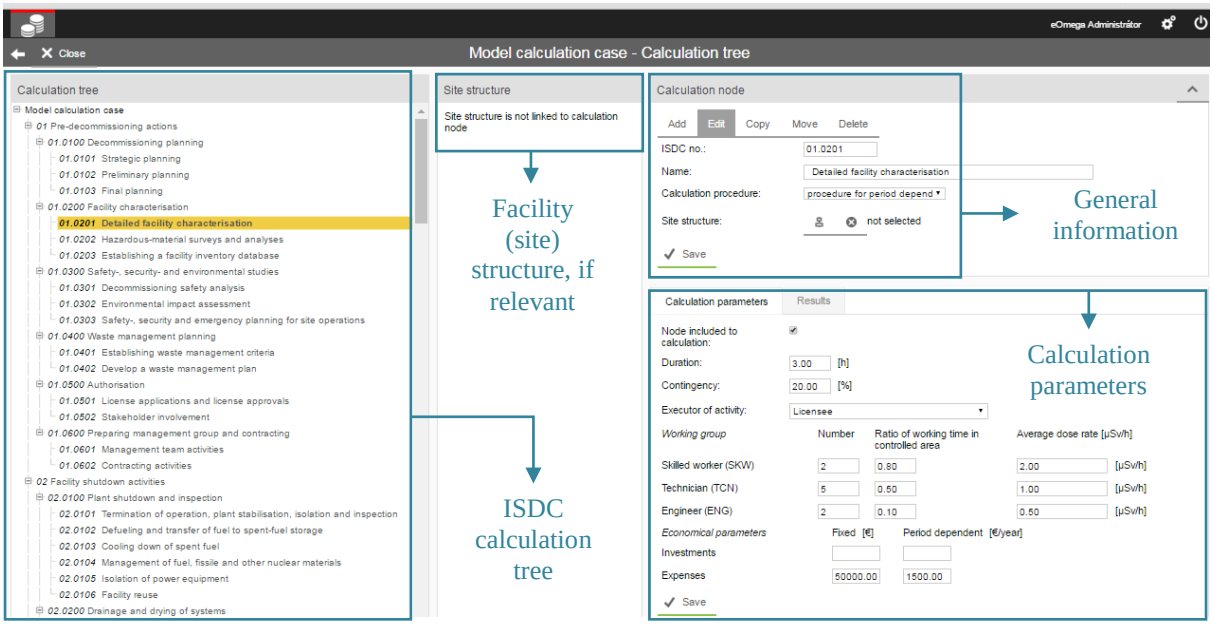

Fig.4. Definition of inventory database in eOMEGA

Unlimited number of decommissioning costing cases should be defined by the user.

D. Performance of calculation

The calculation algorithm applied in the eOMEGA code is based on the ISDC calculation methodology i.e.:

- costs are calculated for each cost category (labour costs, investments, expenses, contingency) - see also Fig.2;
- unit factors approach is applied for the calculation of decommissioning parameters for inventory dependent activities - measurable work activities (dismantling of tank, disposal of waste containers, etc.) are generalized as unit factors that represent calculated quantities (workforce, costs, etc.) related to normalized quantity of input variable (one ton, one container, etc.); moreover the relevant work difficulty factors, representing the work constraints (e.g. using of protective means, limited workspace or access), are then applied.
- duration of the activity together with the work group composition and definition of fixed and period dependent expenses or investments are the basis for the calculation of decommissioning parameters for period dependent activities and collateral costs.

Calculation of waste quantities are performed by using the unique system simulating the material and radioactivity flow in the decommissioning process. This tool allows linking physical and nuclide resolved radiological characteristics (radioactive decay of individual nuclides is also taken into account) of each material item, it means that every parameter of material item is traceable from dismantling (demolition) up to release to the environment or disposal in radioactive waste

repository. It is possible to control the material (waste) flows during the whole decommissioning process. The material flows in the eOEMGA are created with respect to the categories of radioactive waste as recommended by International Atomic Energy Agency [4] but could be adapted to any other waste classification or waste management system [5].

E. Analysis of results, optimisation of calculation case

The following types of results are intended to be generated by the eOMEGA for each calculation case:

- Decommissioning costs presented in the ISDC structure and ISDC cost categories;
- Other decommissioning parameters i.e. workforce and exposure presented in the ISDC structure;
- Waste quantities as defined by the IAEA waste classification [4] or based on the specific waste classification or requirements;
- Schedule of all planned decommissioning activities together with time distribution of the costs and other decommissioning parameters.

The output data should be exported to the relevant standardly used office applications. Moreover, the user friendly tool for performance of sensitivity analysis within the calculation case as well as for benchmarking of several costing cases is included in the eOMEGA solution. These features could facilitate the optimisation process of individual calculation case which is aimed to find the possibilities for reducing the resources needed for decommissioning.

eOMEGA – FUTURE VISION AS A UNIVERSAL COMPLEX PLATFORM

The future vision related to the eOMEGA software is to develop a universal and complex eOMEGA platform as one compact package covering:

- General *ISDC decommissioning costing*, as described in the paper, with additional modules intended to be added:
    - *ISDC probabilistic cost risk assessment* providing the possibility to evaluate selected cost data in order to include the impact of project in-scope and also project out of scope risks on decommissioning costs;
    - *ISDC costing for transition period* between the shutdown and start of decommissioning.
    - *Transforming cost data to ISDC* to be supported by set of conversion matrixes and factors to facilitate the effective benchmarking of decommissioning cost data.
- Other activities of back-end of peaceful use of nuclear energy:
    - *Waste management optimisation* providing the possibility for detailed evaluation of various options for radioactive waste management (operational as well as decommissioning waste) generated within one

or several nuclear facilities (sites) aimed to find the optimal one under the specified conditions.

- *Site remediation* to be used for evaluation of costs for remediation of legacy waste sites, contaminated sites or even large scale areas contaminated after an accident, supported by the extension of the ISDC structure focused on the site remediation.
- *Back end of nuclear fuel cycle* covering the activities related to e.g. long term storage, final disposal or reprocessing of spent fuel.
- *Funding* is intended to be used for evaluation of back end funding in relation to the other modules (decommissioning costing or back end of nuclear fuel cycle) and taking into account the legislative background, conditions for funds collection, contributions of the license holder and revenues from the operations on the financial markets.

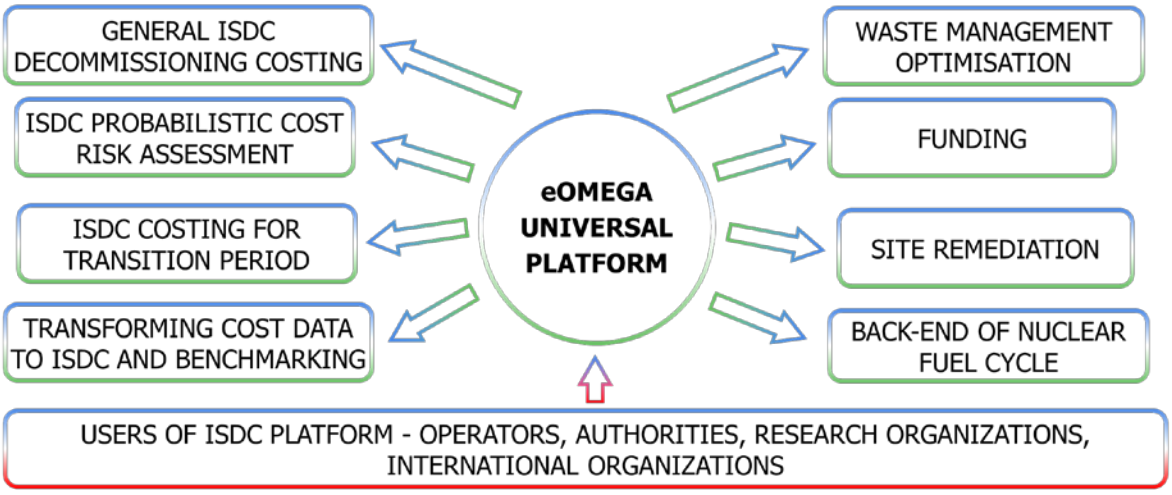

Fig.5. Principal scheme of the universal eOMEGA platform

CONCLUSION

The paper presents the decommissioning costing code eOMEGA with fully implemented ISDC structure, methodology and ISDC costing approach, taking the advantages from about two decades of experience in decommissioning costing and being in line with the international recommendations, best practice and recent trends in decommissioning costing. The eOMEGA is aimed to provide the web-based, flexible, open, transparent ISDC costing code in user-friendly environment and be available to any stakeholder involved in any phase of decommissioning planning process. The tools for sensitivity analysis and benchmarking could, in the planning phase, identify the potential sources for future optimisation of the resources needed for decommissioning. As a future vision, the eOMEGA is intended to be universal and complex platform covering not only the decommissioning costing but also the other activities under the back end of nuclear power engineering.

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