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Prediction of Decommissioning Cost for Kijang Research Reactor Using Power Data of DACCORD

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Currently, there is no universally accepted standard for developing decommissioning cost estimates, or for that matter, any clear reference for the terminology used[1]. Some generalized approaches can be found in IAEA documents. The level of detail of cost estimates and costing approaches may differ, starting from the preliminary costing stages up to final costing. A review of these aspects is given in Ref.[1].

There are 3 types of cost estimate that can be used, and each have a different level of accuracy [1]: (i) 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%. (ii) Budgetary estimate: One based on the use of flowsheets, 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%. (iii) 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%[2].

But also, there is no guideline related to cost estimation when the preliminary decommissioning plan is written in domestic. The cost plans to predict referring to abroad examples as decommissioning cost estimation has still not developed and been commercial method for Kijang research reactor. In Kijang research reactor case, overall scope of business isn't yet decided. Then it is supposed to estimate cost with type (i)[2]. The IAEA project, entitled 'DACCORD' (Data Analysis and Collection for Costing of Research Reactor Decommissioning) performs decommissioning costing after collecting and analyzing the information related to research reactors around the world for several years. Also decommissioning costing method development tends to increase in the each country. This paper aims to estimate preliminary decommissioning cost based on total decommissioning cost per thermal power rate of research reactor presented in DACCORD project' data which is collected by member state.

2. Characteristics of Kijang Research Reactor Facilities

Kijang research reactor is located in Jwadong-ri, Jangan-eup, Kijang-gun, Busan city. Thermal power is 15 MW and type of open-pool reactor. It aims to 1) Production and study of radioactive isotope; 2) Development of critical technology associated with neutron irradiation services; 3) Promotion of reactor export by demonstration of development; 4) Security of steady supply and export production ability of isotope need in domestic. It is composed to reactor building, FMPF(Fission Molybdenum Production Facility) Building, Utility Building, RIPF(Radioisotope Production Facility Building) building, RWTF(Radioactive Waste Treatment Facility) building, other auxiliary facilities. It plans to complete construction in 2017 and then to operate for 50 years.

Table 1. Key Characteristics of Kijang Research Reactor

Reactor type	Open tank in pool
Thermal Power(MW)	**15**
Max. of neutron flux	3.2E+14
fuel type	Plate type
fuel composition	UMo
Concentration	LEU
Coolant	Light water
Cooling method	Lower forced circulation
Flow rate (kg/s)	535
Reflector	Be, Al, Graphite

3. Characteristics for Decommissioned Research Reactor in DACCORD data

Research reactor facilities are used for a variety of purposes, including training, radioisotope production, irradiation of materials for research or safety purposes and industrial processing of material. Many universities and government institutes use these facilities for conducting basic research on material behavior. There are many different types of reactor, and the range of power ratings varies from several watts up to hundreds of megawatts. The complexity varies from relatively simple constructions of critical assemblies to a complexity comparable with power reactors.

The typical period of operation of research reactors and critical assemblies is of the order of 40 years, with typical decommissioning times of 3-5 years for research reactors and about one year for critical assemblies. Some research reactors have been in operation for 50 years or more.

The construction of research reactors varies widely. Relatively simple constructions of critical assemblies can be located within a large laboratory room. Medium size research reactors have a compact construction (mostly embedded in a concrete monolithic structure) located within a single building with a reactor hall and some additional rooms for auxiliary systems. The research reactors at the highest power range have construction features similar to power reactors: a reactor building with a reactor hall, many additional cells for primary, secondary and auxiliary systems and several additional buildings including ones for treatment of operational wastes. Different methods can be used to classify research reactors, e.g. power level, utilization and the type of moderator used:

Research reactors may be classified according to the following main types: open pool reactors, of which TRIGA and SLOWPOKE are specific types; tank reactors, including WWR pool-in-tank reactors; Argonaut reactors; homogeneous liquid reactors; fast reactors; graphite reactors; and others, including critical assemblies and homogeneous solid reactors. The DACCORD project focuses on the open pool research reactors (including TRIGA-type reactors), and WWR pool-in-tank research reactors of Soviet design.

4. Results

Global decommissioning costs from completed decommissioning projects were compiled from various sources for approximately 50 research reactors of the commonly-built types, including a small number of critical assembles. The original cost data was adjusted for inflation in order to correspond to an estimate for the reference year 2013.dfdf

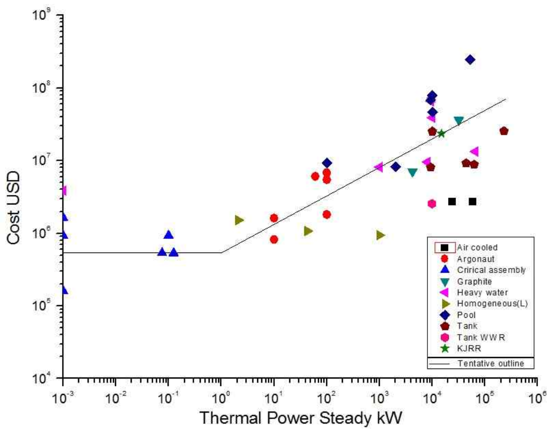

Fig. 1. Actual decommissioning cost of selected reactors vs thermal power, based on the IAEA database

The data suggest a possible relation between the global decommissioning cost and the rated thermal power for reactors, particularly those with a power rating of greater than 1kW. It is possible that there exists a threshold level below which costs are unlikely to fall for zero power or very low power reactors. From the limited dataset considered here this threshold value is in the range \$100,000 ~ \$500,000 (2013 price levels). The cost of dismantling research reactors of power ratings greater than 1kW will generally be greater than \$1 million (2013 price levels) provided all major cost elements are included. At power levels of 1 MW or more, the cost can range from \$1 ~\$10 million (2013 price levels). For power reactors rated at 10 MW or more, the cost may range from \$10~100 million (2013 price levels); the highest-cost reactor included above is the Siloe reactor ($35MW_{th}$) at Grenoble in France, recently decommissioned at a total cost of \$168 million (2013 price levels).

In case of the Kijang research reactor, when thermal power rate is 15MW, decommissioning cost is about \$ 23.5 million (2013 price levels).

5. Conclusions

In this paper, preliminary decommissioning cost is estimated based on total decommissioning cost per thermal power rate of research reactor presented in DACCORD data which is collected by member state.

Although there exists a general tendency for costs to increase with increasing thermal power, the limited data available show that decommissioning costs at any given power level can vary widely, with increased variability at higher power levels. Variations in decommissioning cost for the research reactors of the same or similar thermal power are caused by differences in reactor types and design, decommissioning project scopes, country-specific unit workforce costs, and other reactor or project factors. An important factor for the DACCORD data may be related to differences in the scope; it is being evident that some estimates are largely focused around dismantling costs, with other normally-significant costs being largely ignored, for example, waste management costs may not include disposal costs or licensing-related costs may have been excluded. For this reason, the presented data points only provide an indication of the relationship between overall costs and power levels. To estimate decommissioning cost using only thermal power has limitations but, if decommissioning cost including inventory and others which is calculated by computer code such as MCNP/FISPACT is estimated, more exact cost values would be able to obtain.

REFERENCES

[1] Financial Aspects of Decommissioning, IAEA-TECDOC-1476, IAEA, Vienna, 2005.

[2] Cost Estimates for Decommissioning Nuclear Reactors Why Do They Differ So Much?, UNIPEDE, 1998.
[3] Data Analysis and Collection for Costing of Research Reactor Decommissioning, Version.28, pp.14-17, 2015