2021 International Nuclear Atlantic Conference – INAC 2021
Virtual meeting, Brazil, November 29 – December 2, 2021

ISBN: 978-65-594-1256-3

AN ESTIMATE OF THE COSTS INVOLVED IN EACH DECOMMISSIONING STRATEGY FOR PWR TYPE NUCLEOELECTRIC PLANTS

Maria Vitória A. de Oliveira[1], and
Giovanni L. de Stefani[2]

[1] *maria.oliveira@coppe.ufrj.br*
[2] *laranjogiovanni@poli.ufrj.br*

1. Introduction

Coal, gas and nuclear power plants have their finite activities beyond which it is not economically interesting to operate them. In theory, the first nuclear power plants were designed for a life of about 30 years and, in some cases, many power plants were able to run for a period of operation much longer than the initial design. The newer plants are designed for a useful life of around 40 years, in some cases extended to another 20 years. At the end of the useful life of any plant, it needs to be deactivated, cleaned and demolished so that the site can be made available for other purposes (MOREIRA et al, 2017).

The term decommissioning, for nuclear power plants, includes all radioactivity cleanup and the progressive dismantling of the plant. This can start with the operator's decision to delete it or declaring it to be permanently removed from the trade. For practical purposes, it includes removal of fuel and removal of coolant, although the NRC at least defines it as strictly starting only after the fuel and coolant are removed. The process is concluded with the termination of the license after the decontamination is verified and the residues removed (USNRC,2005; CNEN 133,2012).

The activities of power reactors started their activities in the 1950s, right after the Second World War, and, with the estimated useful life of these reactors around 40 years, in some cases being extended for another 20 years, several plants had their activities ended in the 90's. Between 1970 and 2000, the USA carried out several studies in order to establish technology, safety and costs associated with the decommissioning process of different types of reactors (WNA, 2021).

There are three possible decommissioning strategies, namely: (1) immediate dismantling (**decom**), (2) delayed dismantling (*safstor*) and (3) confinement (*entomb*). The first strategy (decom) foresees that all equipment, structures and parts of the plant containing radioactive contaminants are removed or decontaminated shortly after the end of plant operations to levels that allow the site to be released for unrestricted or restricted use. In the second strategy (*safstor*), the process occurs after a Safe State Period (PES), during which the NPP remains disabled so that the radiological activity decays to levels that allow the dismantling at lower radiation doses for the work teams. The last strategy (*entomb*), on the other hand, is only used in extreme cases, in which radioactive systems, structures and components are confined in concrete structures, or sarcophagi. The three exposed strategies are defined in detail in the CNEN 133/2012 resolution.

For each type of strategy adopted by the operating organization there will be an associated cost. Resolution CNEN 133/2012 stipulates that the operating organization must present the Preliminary and Final Decommissioning Plans for the plant in accordance with the strategy used.

For this work we will estimate the total cost of decommissioning a PWR-type plant. The calculations will be based on data obtained from the Almirante Álvaro Alberto Nuclear Power Plant (CNAAA), considering the regulatory guide 1202, Standard Format and Content of Decommissioning Cost Estimates for Nuclear Power Reactors (USNRC, 2005). The purpose of this estimate is to present the main precautions to obtain good cost values from the operation phase until the end of decommissioning.

2. Methodology

The total cost of decommissioning will follow the model proposed by *Model de Jeong et al (2007)*:

$$CD = \sum_{i=1}^{n} C_i \tag{1}$$

Where, C_i is a set of tasks, and the total cost is the sum of these groups, which we can list below:

1) Project Preparation and Management;
2) Shutdown of the plant;
3) Decontamination and Dismantling;
4) Handling and managing tailings;
5) Restoration of the site;
6) Other activities.

3. Results and Discussion

According to the reference values established by the NRC (USNRC, 2005), the estimated cost of decommissioning the Angra 1, Angra 2 and Angra 3 plants, and considering the thermal power approximately 2000 MWt (Angra 1) and 4000 MWt (Angra 2 and 3), the reference value required in the fund to fund the decommissioning of Angra 1 would be US$435 million. For Angra 2 and 3, the estimate would be around US$ 490 million.

The estimates presented here refer to those presented by Moreira et alii, 2017 (pp. 365).

In this work, it is intended to obtain more realistic data from the details of the process and data from the three plants.

An interesting point, the projection of values for the decommissioning of CNAAA will have the base year of construction of Angra 3 in 2018, as provided for in the CNAAA Decommissioning Plan launched in 2013 by Eletrobras/Eletronuclear (Eletrobras/Eletronuclear, 2013). Based on this Plan, Angra 1 starts decommissioning in 2025, Angra 2 in 2040 and Angra 3 in 2058. In order to achieve the maximum decay of Angra 3, the literature tells us that the PES can be started after 30 years of radioactive decay and, thus, it is possible to further mitigate the costs involved in the nuclear power plant decommissioning process. Considering the period approximately 30 years to decommission Angra 3, the strategies adopted for Angra 1 and 2 would be *safstor* and Angra 3 *decom*.

Acknowledgements

Thanks the UFRJ Nuclear Engineering Program (PEN/COPPE/UFRJ) for the training provided to me so for and the CNPq funding agency for providing financial assistance.

References

[1] MOREIRA, L. M. J; BERECHE, P. R.; MAIORINO, R. J. Questões sobre Energia. Rio de Janeiro. Ed. Interciência. 2017.

[2] USNRC, Regulatory Guide 1.202. Standard Fromat and Contento f Decommissioning Cost Estimates for Nuclear Power Reactors. USNRC, frebuary 2005.

[3] CNEN. Resolução CNEN Nº 133. Descomissionamento de Usinas Nucleoelétricas. Ministério da Ciência

e da Tecnologia, Comissão Nacional de Energia Nuclear, 2012.

[4] WNA. Decommissioning nuclear facilities. Word Nuclear Association. Disponível em: http://www.word-nuclear.org./info/inf19.html. Acesso em: 20 de julho de 2021.

[5] JEONG, K et al. Structure and elements for the decommissioning cost estimations of nuclear research reactors. Annals of Nuclear Energy, v.34, p. 326-332, 2007.