Nuclear Power Plant Decommissioning and Reuse Case Study

Young-Il Na[a*], Hyung-Woo Seo [a], Chan-Geun Park[a], and Gang-Woo Ryu[a]
[a]*Korea Hydro & Nuclear Power (KHNP) Central Research Institute, 70, 1312-gil, Yuseong-daero, Yuseong-gu, Daejeon, 34101, Republic of Korea*
[*]*Corresponding author: eaglewater012@khnp.co.kr*

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1. Introduction

Domestic nuclear power plants have been reaching their design lifetimes as time goes by. Kori Unit 1 and Wolsong Unit 1 have reached their design life and are preparing for decommissioning, marking the first time South Korea faces the issue of decommissioning a power plant. While there is ongoing discussion on extending the operational period through continued operation and safety assessments, discussions also focus on how to reuse the site accordingly. In order to learn about how other countries around the world clean up sites after the end of an atomic power plant's lifecycle, we will be examining cases in various nations.

2. Methods and Results

To restore the site of a nuclear power plant, radiation surveys must be conducted on the final site state (FSS). In many countries abroad, they present restoration criteria for sites by presenting their respective effective doses, and in domestic nuclear power plants, they ensure that the annual effective dose value does not exceed 0.1 mSv.

1. IAEA

The International Atomic Energy Agency provides guidance on opening up sites in regulatory management through its Safety Standards Series WS-G-5.1. Based on the protection system of the International Commission on Radiological Protection (ICRP), WS-G-5.1 applies principles of justification, dose limits, and optimization of protection. It stipulates an individual's annual effective dose limit to maintain unrestricted reuse of the site at or below 0.1~0.3 mSv and recommends national selection.

2. USA

In the United States, decommissioning is currently underway with annual dose limits of 0.25 mSv being used to assess site deregulation Based on that criteria, scenarios have been constructed for each remaining material to derived concentration guideline level (DCGL) and evaluate them. The following table shows representative materials evaluated at four typical nuclear power plants.

Table 1. USA Decommissioning Status [1]

	Zion	Rancho Seco	Connecticut Yankee	Humboldt Bay
Soil	O	O	O	O
Building, Structure	X	O	O	O
Buried Pipe	O	O	O	X
Underground Water	X	X	O	X

2.1 Zion

Zion were commissioned in respectively 1973 and 1974, and decommissioned between 1998 and 2020. Zion initiated deregulation under unlimited use conditions and fulfilled the regulatory release by assessing residual radiation concentrations in soil and underground piping systems. They assumed a contaminated layer thickness of only 0.15 meters for surface soils and used a topsoil restoration layer of 3.45 meters with a resident farmer scenario. Input parameters included site-specific information to reflect the characteristics of the property. For underground piping, they evaluated two scenarios - one considering surface contamination of buried pipes while leaving them in place, and another where they were excavated and brought above ground. This also consider input parameters classified as behavioral or metabolic types, along with site-specific factors.

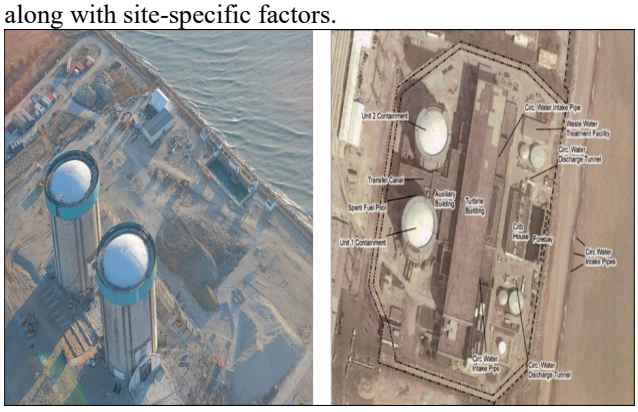

Fig 1. Zion NPP Site View [2]

2.2 Rancho Seco

As the target population for contamination is limited to industrial facility workers, the nuclear power plant

operator considered scenarios applicable to industrial workers when calculating DCGLs. The DCGLs for soil on site were calculated using an industrial worker scenario. For buildings that will be reused, the Building Occupancy scenario was applied; and for restricted-access containment structures, the Renovation and Demolition scenarios were used. DCGLs for buildings were calculated considering the type of pollution in the building, distinguishing between surface and volumetric contaminations. Additionally, DCGLs were also calculated for pipes buried underground within the premises. During the Site Characterization phase, the operator demonstrated through groundwater monitoring that there was no water contamination, which led to its exclusion from the DCGL calculation targets.

2.3 Connecticut Yankee

The Connecticut Yankee nuclear power plant site's DCGL for unrestricted release of the site was calculated based on four factors: soil at the site, remaining structures after decommissioning, contaminated groundwater, and future groundwater. For Connecticut Yankee, an assessment was performed with a contamination layer thickness of 3 meters and using the residence farmer scenario as input parameters. The same behavioral, metabolic type, and bud characteristics data were used as for Zion. For Connecticut Yankee, like at Ranchos Seco, dose assessments were made for buildings and structures, but with different pollution form distribution patterns. Assessments were also conducted for underground pipes under the scenario where groundwater becomes polluted by passing through contaminated pipelines.

1.4 Humboldt Bay

The Humboldt Bay Power Plant (HBPP) site is an industrial area that supplies electricity to surrounding regions and includes both nuclear power plants as well as non-nuclear facilities such as the Humboldt Bay Generating Station (HBGS), which is a 163 MWe natural gas plant that began commercial operation in 2010 with a projected lifespan of around 30 years. As such, given that the HBGP site will continue to be used for its intended purpose even after decommissioning of Unit 3 at HBPP, there is low likelihood of the site being repurposed for non-industrial use. However, the utility company has taken a conservative approach when developing conceptual models and scenarios for calculating DCGL by assuming post-decommissioning occupants would be general residents rather than industry workers on the premises.

The DCGL for unrestricted decommissioning of the site at the HBPP nuclear power plant was calculated for soil and residual buildings after decommissioning. The buried facilities and contaminated groundwater in the HBPP nuclear power plant's long-term plan were not considered. During the site characterization phase, the operator demonstrated through monitoring that there is no groundwater pollution and excluded them from the calculation of the DCGL.

3. EUROPE

In Europe, standards are applied according to each country's criteria. In Germany, for example, only post-decommissioning site restoration is addressed under radiation protection legislation with a standard of 0.01 mSv. There is no limit on opening sites for restricted use; unrestricted agricultural use is allowed instead. Spain requires that after decommissioning, residual radioactivity in soil does not exceed an effective dose rate of 0.1 mSv and buildings and structures must satisfy a dose rate of 0.01 mSv. The natural background radiation level at released sites should be equal to the pre-use natural background radiation levels, and limited site openings require additional requirements to be more specific.

3. Conclusions

Domestically, there is no experience in commercial nuclear power plant decommissioning yet; however, we must prepare for its implementation by referring to precedents abroad. Site reuse criteria should also be established and appropriate values of DCGLs per radionuclide need to be designated in order to proceed with nuclear power plant decommissioning appropriately. In Korea, these procedures are being established based on foreign examples as well.

REFERENCES

[1] Kyung Hee University, "Study on Optimization Method Decommissioning Site Remediation", 2016.
[2] Wikipedia, "Zion Site View"
[3] IAEA Safety Guide WS-G-5.1, "Release of Sites from Regulatory Control on Termination of Practices"