A Study on Optimized Management Options for the Wolsong Low- and Intermediate - Level Waste Disposal Center in Korea – 13479

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ABSTRACT

The safe and effective management of radioactive waste is a national task required for sustainable generation of nuclear power and for energy self-reliance in Korea. Currently, for permanent disposal of low- and intermediate-level waste (LILW), the Wolsong LILW Disposal Center (WLDC) is under construction. It will accommodate a total of 800,000 drums at the final stage after stepwise expansion. As an implementing strategy for cost-effective development of the WLDC, various disposal options suitable for waste classification schemes would be considered. It is also needed an optimized management of the WLDC by taking a countermeasure of volume reduction treatment. In this study, various management options to be applied to each waste class are analyzed in terms of its inventory and disposal cost. For the volume reduction and stabilization of waste, the vitrification and plasma melting methods are considered for combustible and incombustible waste, respectively.

INTRODUCTION

The safe and effective management of radioactive waste is a national task required for sustainable generation of nuclear power and for energy self-reliance in Korea. Since the initial introduction of nuclear power to Korea in 1978, a rapid growth in nuclear power has been achieved; as of the end of 2012, there are 23 commercial nuclear units in operation, including 19 PWRs and 4 CANDU reactors, and 5 PWRs are under construction in Korea. The construction program for future nuclear power plants (NPPs) is also ambitious. This large nuclear power generation program has already produced a significant amount of radioactive waste, and the amount of waste is steadily growing. Moreover, due to a wide application of radioisotopes, the annual generation rate of related radioactive waste from industries, hospitals, and research institutions is also increasing. Currently, radioactive waste in Korea is classified into two categories according to their specific activity and degree of heat generation as low- and intermediate-level waste (LILW) and high-level waste (HLW). As LILW has accumulated at four (4) NPP sites and other nuclear installations, the necessity to find a final repository has increased. After the selection of the final candidate site for a LILW disposal in Nov. 2005, a construction and operation license was issued in July 2008 for the Wolsong LILW Disposal Center (WLDC). The 200 hectare site is located in the southeastern part of Korean peninsula. The WLDC is under construction with the completion target by the middle of 2014. The WLDC is an underground silo type disposal facility for the first phase of operation of 100,000 drums of waste (35,200 m^3). It will accommodate a total of 800,000 drums at the final phase after stepwise expansion [1].

The current disposal cost per unit drum, ranges from 650 to about 1,000 US dollars and, is relatively high compared to the costs in foreign countries such as France, Japan, Sweden, etc. Meanwhile, the anticipated amount of LILW generation is shown to be more than 1 million drums even in the optimistic scenarios. This is a far cry from the previous expectation when the WLDC was planned, and is due to the rapid expansion in the nuclear energy program. Therefore, an implementing strategy for optimized management of the WLDC disposal facility is needed. The strategy must include and balance the necessary levels of safety with the cost-saving. In this study, various disposal options and volume reduction methods under consideration are analyzed in terms of inventory and disposal cost.

NEW WASTE CLASSIFICATION SCHEME AND EXPECTATION OF WASTE GENERATION

New Waste Classification Scheme

As an implementing strategy for cost-effective development of the WLDC, various types of disposal facility were considered for the different categories of radioactive waste in accordance with the recent International Atomic Energy Agency (IAEA) recommendations [2] based on a risk-graded approach. The usefulness of a new waste category, Very Low Level Waste (VLLW), was recognized. This category is sufficiently limited in both total and specific activity so as to allow disposal in a landfill with minimal engineered barriers. By providing disposal facilities with a range of depths and engineering sophistication, wastes may be allocated to disposal facilities in a cost-effective way. By applying the IAEA recommendations, the low and intermediate level class of waste would be divided into three subclasses of Very Low Level Waste (VLLW), Low Level Waste (LLW), and Intermediate Level Waste (ILW) [2]. The Korean regulatory body is in the process of revising the radioactive waste classification. The new proposed classification scheme is shown in Table I along with the current Korean classification scheme.

TABLE I. New Classification Scheme of Radioactive Waste in Korea (Draft)

Waste Classes		Disposal Options
Existing	Revision (Draft)	
EW (Exempt Waste)	EW	Landfill, Incineration or Reuse
LILW	VLLW	Trench type Near-surface Disposal
	LLW	Engineered vault type Near-surface Disposal
	ILW	Intermediate-depth Cavern or Silo Disposal
HLW(SNF)	HLW(SNF)	Deep Geological Disposal

Long-term Waste Generation Predictions

According to the 5th Plan of Electricity Supply and Demand, 11 more NPPs will be added by 2024 (Scenario #1). The 1st Basic Plan for National Energy Resources in Korea is projecting construction of 40 NPPs by 2030 (Scenario #2). The anticipated amount of new LILW generation is shown in Table II and is estimated to be about 1 million drums in the assumed scenarios. This is more than the previous expectation which was used to plan the WLDC. In the Table, surface dose from the waste drums is taken into account. It is the determinant for the waste operations and maintenance (O&M waste) categorization. The surface dose (0.03 mSv/hr) estimated from Dry Active Waste (DAW) drums containing 100 Bq/g of Co-60 is assumed the upper limit for VLLW. The concentration limit for ILW is the same as the current criteria of LILW, which is 4,000 Bq/g of alpha radionuclides within the drum. The anticipated amount of Radioisotopes (RI) waste generated from domestic RI users and research institutes is included in the O&M waste group. The amount of decommissioning waste in each waste category was estimated by using the waste generation ratio 4:29:67 for ILW:LLW:VLLW [3]. Using this ratio, the total amount of decommissioning waste assumed for each reactor is 14,500 drums.

MANAGEMENT STRATEGY OF LILW

Cost-saving From Implementing New Waste Classification Scheme

It can be seen from the Table II that the large amount of VLLW and LLW demand more economic disposal methods/strategies which can be justified on the basis of lower activity level. Various management options which can be applied to each waste class are considered and analyzed in terms of inventory and disposal cost. The IAEA waste classification scheme was applied to Waste Generation Scenario #2, 40 NPPs. For this scenario, about 1.04 million drums of waste will be generated. Unit disposal costs were estimated for each type of waste from the consideration of life cycle phases, i.e. pre-operational phase, operational phase, closure and post-closure phase. The estimated costs of 6,500 U.S. Dollars/drum for the ILW, 5,500 USD/drum for LLW, and 4,200 USD/drum for VLLW were applied for the cost comparison. Implementing the new classification scheme will result in a cost reduction per drum of about 20%. Therefore, the Korea Radioactive Waste Management Corporation (KRMC), which is the dedicated implementing organization for radioactive waste management business in Korea, is continuing efforts on the second phase construction of the WLDC. The second phase is the Engineered-vault type near-surface disposal facility and has a target completion date toward the end of 2016. The basic plan for the 2nd phase disposal facility accommodating up to 125,000 drums was set up in 2011. At the same time, the KRMC is preparing for VLLW disposal facility as the third phase within the WLDC. Some ILW wastes would be allocated for intermediate-depth disposal, particularly borehole disposal for disused sealed radioactive sources as the long-term plan.

TABLE II. Long-term prediction of LILW generation

Unit : 1,000 Drums

Scenario / Category	34 NPPs Operation			40 NPPs Operation		
	O&M Waste[i]	Decomm. Waste[ii]	Total	O&M Waste	Decomm. Waste	Total
ILW	0.1	21	21	0.1	25	25
LLW	321	144	465	348	169	517
VLLW	92	337	429	101	395	497
Total	414	502	915	449	589	1,038

Note: i. '100drum/reactor,yr' for NPP operational waste is assumed., Non-NPP wastes are included in the NPP operational waste group.
ii. '14,500drum/reactor' for decommissioning waste is assumed.

Cost-saving From Implementing Waste Treatment In The WLDC

Both of scenarios mentioned above give rise to the anticipated amount of LILW generation to be about 910 thousand drums and 1 million drums, respectively. This is based on the assumption of 14,500 drums of decommissioning waste being generated. If the IAEA basis for estimating the decommissioning waste is used a total about 22,500 drums will be generated [4] and the accumulated total amount of LILW waste generated is approximately 1.2 million and 1.36

million drums for each scenario. In either case, the amount of waste is a far cry from the previous expectation and exceeds the total disposal capacity of the WLDC (0.8 million drums).

Considering a twenty-year effort to secure a LILW disposal site, securing a 2^{nd} site for radioactive waste disposal in a timely manner cannot be guaranteed. Therefore, optimized management of the WLDC via volume reduction treatment is needed. Typically, more economic methods employ volume reduction coupled with various methods of disposal. Vitrification and plasma melting methods are being considered for volume reduction and stabilization of combustible and incombustible waste, respectively. Figure 1 represents a schematic of the proposed radioactive waste treatment in the WLDC. If this treatment concept is implemented in the WLDC, about 70% of waste volume reduction and a corresponding disposal cost saving could be achieved with consideration of equipment installation cost and operating expenses. In the calculations, typical volume reduction ratios shown in Table III were assumed. The KRMC plans to complete construction of the waste treatment facility by the end of 2017.

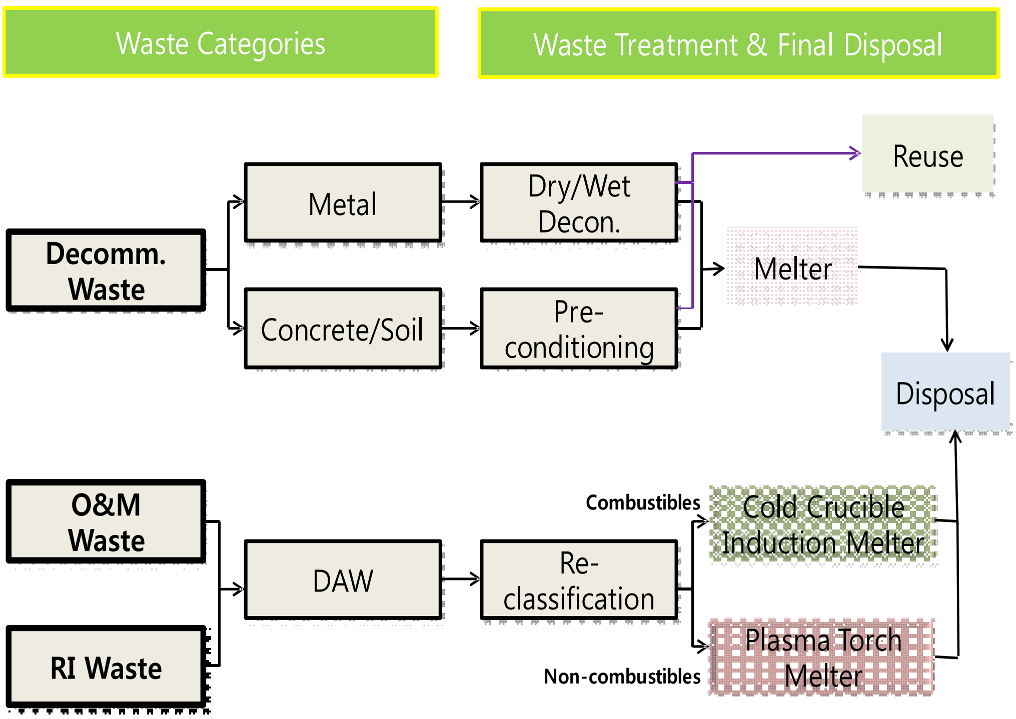

Fig.1. Schematic of radioactive waste treatment at the WLDC

TABLE III. Volume reduction expected from waste treatment facility operation

Waste type		Treatment method	Volume to be reduced in Scenario #2 (200L drum)	Volume reduction ratio (-)
Dry Active Waste	Combustibles	Vitrification	150,000	1/20
	Non-combustibles	Plasma torch melting	27,000	1/6
Concrete & Soil		Thermal treatment & melting	290,000	7/20
Non-NPP waste (RI waste etc.)		Super compaction	150,000	4/5
Large component metallic waste		Decontamination/ Cutting/Melting	225,000	1/7
Total			842,000	

CONCLUSIONS

Top priority on safety is the most important fundamental principles of the national radioactive waste management program in Korea. At the same time, it is also important to provide cost-effective ways of implementation without sacrificing the necessary levels of safety. Much effort has been devoted to the site selection of a LILW repository, and it is not expected to find another LILW disposal site. In response to the necessity of cost-effective management of the WLDC, the implementing strategies of various disposal options and volume reduction methods were considered and analyzed. The KRMC is continuing its efforts to set up the strategies toward the optimized management of the WLDC.

REFERENCES

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