Effects of a Capital Investment and a Discount Rate on the Optimal Operational Duration of an HLW Repository

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1. Introduction

This study aims to estimate the effects of a capital investment and a discount rate on the optimal operational duration of an HLW repository.

According to the previous researches of the KRS(Korea Reference System) for an HLW repository, the amounts of 7,068,200 C$K and 2,636.2 MEUR are necessary to construct and operate surface and underground facilities[2,5]. Since these huge costs can be a burden to some national economies, a study for a cost optimization should be performed. So we aim to drive the dominant cost driver for an optimal operational duration.

A longer operational duration may be needed to dispose of more spent fuels continuously from a nuclear power plant, or to attain a retrievability of an HLW repository at a depth of 500 m below the ground level in a stable plutonic rock body. In this sense, an extended operational duration for an HLW repository affects the overall disposal costs of a repository.

In this paper, only the influence of a capital investment and a discount rate was estimated from the view of optimized economics. Because these effects must be significant factors to minimize the overall disposal costs based on minimizing the sum of operational costs and capital investments.

2. Cost estimation terms

We used the KRS (Korean Reference System) that was developed through collaboration with POSIVA of Finland, and also considered such a repository with the cost objects, which are shown in Figure 1[5].

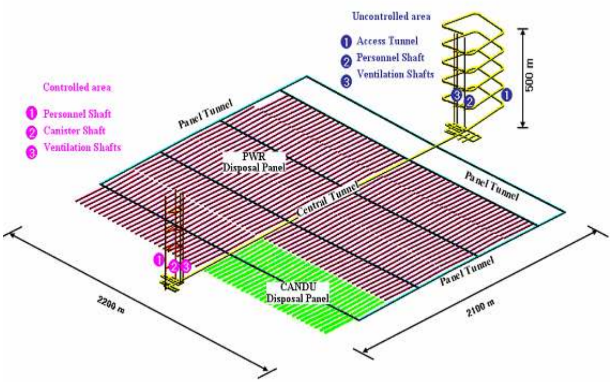

Figure 1. Sketch of an underground facility for an HLW repository

The schedule of the project to construct a repository is shown in Figure 2. In the KRS(Korean Reference Disposal System), the duration of disposing the PWR and CANDU spent fuels into disposal holes is called as an operational duration. So the feasibility study of operating a repository for 55 years should be performed in view of its economics' perspective.

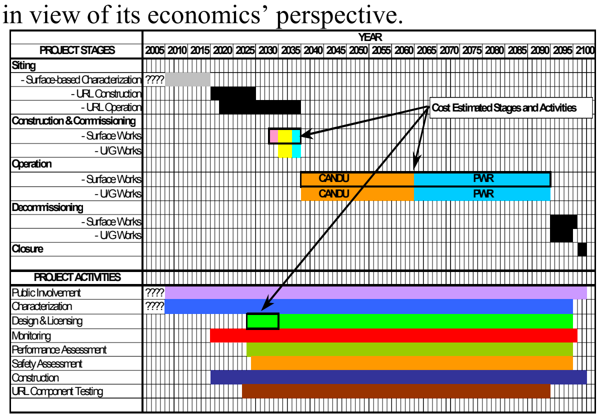

Figure 2. Estimated Project Schedule Showing Project Stages for KRS-1 Implementation and Project Activities that Occur Continuously or Sporadically throughout All Project Stages. Arrows show Stages and Activities that are included in the cost estimate[2].

The main items for the operational costs are composed of the backfilling costs of the tunnels, bentonite costs of the disposal holes, and the personnel costs. Among these costs, it was estimated that a significant charge for the operational costs was the personnel costs.

Main principle for the disposal schedule is expected to start from disposing of the first CANDU canisters in 2040. Annual disposal rates are shown in Table 1 [5].

Table 1. Annual disposal rates.

Time-span	2040-2041	2042-2044	2045-2047	2048-2049	2050-2065	2066-2095
Average rate (canisters/year)	44	74	102	131	146	380
Disposal canisters	CANDU	CANDU	CANDU	CANDU	CANDU	PWR

To calculate the operational costs and capital investments to dispose of 36,000 tU of spent fuels, 4.36% was used for the discount rates and the interest rate. These measures were fixed by Article 50 of the Korean Electricity Enterprise Act.

3. Cost estimation Method

Formula 1 can represent the disposal costs of the PWR and CANDU spent fuels. The overall disposal costs can be divided into two parts such as direct costs and overhead costs[3]. In this equation, we assumed a cost function with a linearity[1].

$$C = c_i(x_1, x_2) = \sum_{i=1}^{n} r_i y_i = \sum_{i=1}^{n} DC_i + \sum_{i=1}^{n} IC_i$$

....(1)

where, x_1 , x_2 , DC_i , IC_i means PWR canister, CANDU canister, direct cost and indirect cost of i-th product, respectively. r_i indicate unit price or ratio, and y_i is the amount or measure of the cost drivers.

The total costs represent the sum of the operational costs and the capital investment[4], and it can be written as Formula (2)-(3).

Total cost = operational cost + capital investment .... (2)

$$\text{Operational cost} = \sum_{i=1}^{k} \frac{OP_i}{(1+r)^i} ,$$

$$\text{Capital investment} = \sum_{i=1}^{k} \frac{CI_i}{(1+r)^i}$$

$$OP_i = \sum_{i=1}^{k} [\text{Unit operational cost} \times \text{Number of canisters}]$$

Optimization of the total cost =

$$\text{Min} \sum_{i=1}^{k} (1+r)^{-i} [\ OP_i + CI_i\ ] \ ....\ (3)$$

Where, r = discount rate, i = the operational duration of an HLW repository.

4. Result of Cost estimation

Figure 3 and Figure 4 show the effects of a capital investment and a discount rate for an overall disposal costs, which is based on the conceptual design of an HLW repository. In addition, Table 2 shows the optimal operational duration in terms of a discount rate and a capital investment.

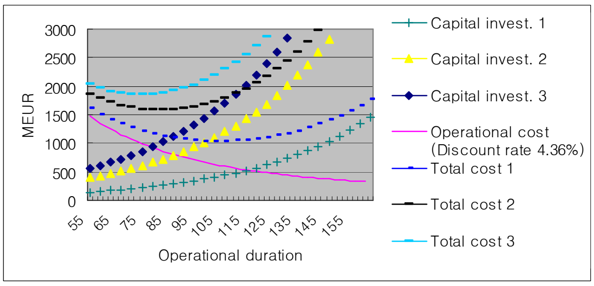

Figure 3. Effects of a capital investment

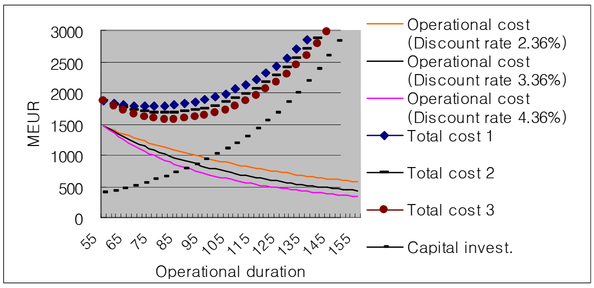

Figure 4. Effects of a discount rate

Table 2. Comparison between a discount rate and a capital investment

Optimal Operational Duration			
Discount Rate[%]	Years	Capital Investment[MEUR]	Years
4.36	83	144.8	103
3.36	79	396	83
2.36	75	560.9	75

5. Conclusions

This study provides an insight to better understand the effects of a capital investment and a discount rate with respect to an HLW repository.

By the efforts of a cost optimization for an HLW repository, it was found that the capital investment and a discount rate will be important variables to minimize the overall disposal costs. In addition, the optimal operational duration of an HLW repository based on the Korean reference disposal system was about 83 years.

We expect that a refined cost optimization technique for an HLW repository, which covers all factors including social costs, will be continuously sought in the future.

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