Economic Evaluation of Decommissioning Cost of Nuclear Power Plant in the National Electricity Plan in Korea

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1. Introduction

Decommissioning cost of a nuclear power plant includes the costs related with dismantling a nuclear power plant, disposal of a spent fuel and of a low/medium radioactive waste. The decommissioning cost is different from the other expenditures in that it is occurred after the reactor finishes its commercial operation. In this respect, the electricity act was enforced to secure provisions for decommissioning a nuclear power plant during its commercial operation. The purpose of this study is to provide economic evaluation and economic cost for a decommissioning when the cost of a decommissioning is provided as one of input to the national electricity plan. Therefore, this study does not deal with whether the estimated amount of a decommissioning cost is just or not. This study focuses how to transfer the estimated decommissioning cost given in the electricity act to the economic cost, which can be used in the national electricity plan.

2. Review on the decommissioning cost of a nuclear power in the national electricity plan

The decommissioning cost is included in the O&M cost of a nuclear power in WASP, electricity planning model. The O&M cost is calculated based on the wages and expenditures occurring during the plant's operation, and the cost is provided by KHNP(Korea Hydro & Nuclear Power Co.) to the national electricity plan.

In the 3rd Basic Plan of Long Term Electricity Demand & Supply[2], the cost input data of a decommissioning was calculated based on the provisions enforced by the electricity act. The amount of provisions for the decommissioning is specified in equation (1).

$$\textit{Initial Provision} = \textit{estimated cost} \times (1+\textit{escalaltion rate})^{\textit{period of escalation}} / (1+\textit{discount rate})^{\textit{period of discount}}$$
$$\textit{Annual Provision} = \textit{initial provision} \times \textit{discount rate}(1+\textit{discount rate})^{n-1} \quad (1)$$

Escalation and discount rates were specified as 2.3% and 4.36% respectively[1]. The parameters are to be adjusted every 5 years.

The estimated costs specified in the electricity act are in Table 1.

Table 1. Estimated cost of decommissioning nuclear power[1]

		Estimated cost(constant price in the end of 2003)
Provisions for dismantling/unit		325.1 billion won
Provisions for PWR spent fuel/bundle		410,650 thousand won
Provisions for PHWR spent fuel/bundle		5,795 thousand won
Provisions for radioactive waste disposal/drum	construction	1,766 thousand won
	operation	2,087 thousand won

2.1 Present way

Among the three items listed in Table 1 as the decommissioning, an explanation is only given to the dismantling of a nuclear reactor. The same explanation can be made on the remaining two items. The electricity act specifies that the dismantling occurs 45 years after a nuclear power plant starts to operate commercially with a cost of dismantling of 325.1 billion won, which is in a constant price of the end of 2003. The dismantling cost should be interpreted as something similar to an overnight cost because the cost related with time is not included.

Explanation will be given on the provisions for the dismantling of a nuclear reactor by obeying the electricity act. Let D be the dismantling cost, f be the escalation rate, r be the discount rate and p be the period from the commercial operation to the dismantling of the reactor.

According to equation (1), the amount of provisions at the year of starting commercial operation is calculated to be $D(1+f)^p/(1+r)^p$. For the consecutive years, only compound interest is calculated on the sum of money, which has previously been added to the provisions. Summing the annual requirement of the provisions including initial provision, we get the total amount of provisions for a dismantling in equation (2)

$$\textit{Total provisions for the dismantling} = D(1+f)^p \quad (2)$$

Equation (2) indicates that the total amount of provisions for a dismantling is not affected by the discount rate(r) but by a parameter including the dismantling cost(D), the escalation rate(f), and the dismantling period(p). Discount rate only has an impact on the path to the total requirement of the provision, which is scheduled to be accumulated at the end of a period.

Equation (1) indicates that there is a big difference in the provisions between the first period and the

remaining periods. In the 3rd Basic Plan of Long Term Electricity Demand & Supply, the cost data for the decommissioning of a nuclear power was produced in a way that the provisions at the first period is evenly divided over the life time of the reactor(40 years) while keeping the part of the compound interest unchanged. With this method, the provisions are still not even but a rising trend over most periods. So, the average values for the past 10 years were calculated for all the nuclear power plants and then the values from Uljin#1,2 were chosen because they are the lowest ones.

2.2 Evaluation of the present way

The present way to produce the decommissioning cost of nuclear power in the national electricity plan is irrelevant. The reasons are as follows.

First, equation (1) was provided to specify the provisions, not to calculate the economic cost of a decommissioning. The present way to calculate the economic cost of a decommissioning is rather arbitrary and has no coherent basis.

Second, all the price input data in the national electricity plan are provided at a constant price. However, a decommissioning cost is a current price.

Third, the annual provision in equation (1) is not an economic cost in the sense that the initial provision is enough to make annual provisions because the initial provision bears interest in a compound way in an economy.

3. Estimation of the Decommissioning Cost of Nuclear Power

Economic cost of a decommissioning is calculated for the input data of the national electricity plan. We used a real discount rate of 2.014%, which is produced by using a nominal discount rate of 4.36% and an escalation rate of 2.3% as in equation (1). Nuclear power is assumed to have a capacity of 1,400MW with a PWR type. The estimated cost of a decommissioning is expressed as a constant price as of the end of 2007. All the costs are discounted for the first year of a commercial operation of the plant.

3.1 Dismantling cost

Dismantling is assumed to start to take place 60 years after the first commercial operating year of the plant(The life time is assumed to be 60 years), and then a dismantling is made over 15 years, of which 12 years are for its preparation and the remaining 3 years are for its dismantling. The dismantling cost in table 1 is assumed to occur evenly for the whole period of 15 years.

3.2 Spent fuel disposal and low/medium radioactive waste disposal

The radioactive waste management law passed on March 2008, due to be enforced in January 2009. According to the law, a newly established entity is to be held accountable for the management of the disposal of a spent fuel and a low/medium radioactive waste. Therefore, the management cost which KHNP will pay needs to be calculated. As for the spent fuel disposal, the cost has not been calculated resulting in using the equation (1) excluding an annual provision until 2010, when the cost estimation will be made. In this study, we assumed that the discharged spent fuel be cooled for 7 years within the reactor site, and then be moved to an interim storage facility where it will stay for 50 years[2]. At the end of the period of an interim storage the spent fuel will be disposed. A unit cost of 200 thousand won/kgU for the interim storage is used, and that of 750 thousand won/kgU for the disposal is used in this study[2]. These unit costs are equivalent to the costs in table 1. All the costs are assumed to occur evenly for the considered periods. As for the low/medium radioactive waste, the disposal cost was updated to be 4,550 thousand won/drum, which was used for the economic cost in this study[2].

Table 2 shows the estimated result on the decommissioning cost in this study.

Table2. Decommissioning cost estimation of nuclear power plant
(constant price of the end of 2007)

	Thousand won/kw-Month	Won/kWh (80% CF)	Share of each item
Dismantling	0.185	0.316	22%
Spent fuel disposal	0.565	0.969	67%
Radioactive waste disposal	0.097	0.166	11%
Total	0.848	1.452	100%

The resulting estimated cost appears to be 48.3% less than the cost in the 3rd Basic Plan of Long Term Electricity Demand & Supply. Spent fuel disposal cost is the largest, accounting for 67% of the total decommissioning cost, followed by a dismantling(22%) and a low/medium radioactive waste (11%). The spent fuel disposal cost of 0.969 won/kWh, estimated in this study is comparable with 1mill/kWh, the typical disposal cost of a spent fuel in the United States[3].

4. Conclusions

The equations for making provisions for a decommissioning are irrelevant when producing an economic cost of a decommissioning as input cost data to the national electricity plan. The estimated cost of a decommissioning is suggested to be used as input data in the 4th Basic Plan of Long Term Electricity Demand & Supply, which is being carried out in 2008.

REFERENCES

[1] Final Report on the estimation of unit cost of radioactive waste spent fuel disposal, Decommissioning Committee of Nuclear Power, 2008. 5.21
[2] The 3rd Basic Plan of Long Term Electricity Demand & Supply, MOCIE, 2006.
[3] Cost Estimating Guidelines for Generation IV Nuclear Energy Systems, EMWG, September 26, 2007