Application of a Parametric Sensitivity and Uncertainty Analysis Method on Economic Evaluation of SSC Improvement Plan

Eunsub Yun and Myung-Hwan Boo
Korea Hydro & Nuclear Power Co., LTD, NETEC
Corresponding author: esyun@khnp.co.kr

1. Introduction

EPRI developed two economic evaluation tools, LcmVALUE [1] and LcmPLATO [2]. KHNP has used the LcmVALUE tool to assess the mid-term and long-term structure, system and components (SSC's) investment plan. LcmVALUE uses the investment cost, failure rate, preventive maintenance cost, and other input parameters to calculate the net present value (NPV) and benefit/investment (B/I) ratio. The results are useful for selecting the most cost-effective investment plan. This tool shows just one result, namely the amount gained or lost. However, the input parameters can be changed by a foreign effect such as the market environment or by their own inaccuracies (such as the failure rate of the SSC). Accordingly, a parameter sensitivity analysis and an uncertainty analysis are needed to determine the influence of changes in the input parameters. We introduce the two methods of analysis as well as a newly developed economic evaluation program.

2. Parameter Sensitivity Analysis

2.1 Method

A parameter sensitivity analysis is used to calculate the degree of influence that input parameters have on the results of an economic evaluation. Our parameter sensitivity index is defined in Eq. 1 as the ratio of the output value change rate to the input value change rate. In an economic evaluation of an SSC investment, the input parameters are the discount rate, the lost power generation cost, the failure rate, the maintenance costs, and the investment costs. The output value is defined as benefit value of an improvement plan to the current maintenance plan.

$$\text{Sensitivity Index} = \frac{\text{Output Value Change Rate}}{\text{Input Value Change Rate}} \quad (1)$$

2.2 Discussion of Sensitivity Analysis

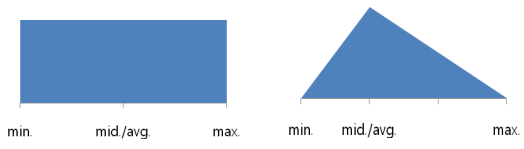
Sensitivity analysis of several input parameters shows two things: the input parameter's impact factor on the economic evaluation result; and the most important parameter for the economic evaluation. Generally, any parameter that has a sensitivity index greater than 1 is considered to have a big impact on the results. The relatively acute input variables are the investment costs and the maintenance costs. However, failure rate and the lost production hours are relatively inaccurate, because their estimated values are usually based on statistics from other plants. Furthermore, the actual value varies significantly from case to case. If the sensitivity index of a relatively accurate parameter has a high ranking, only small variations can be expected in the economic evaluation results. Conversely, if a relatively inaccurate parameter scores highly in the sensitivity index, the economic evaluation results are likely to vary significantly and be less reliable.

3. Uncertainty Analysis

3.1 Method

The uncertainty analysis method uses a Monte Carlo simulation process. EPRI also tried a random sampling economic evaluation by using LcmVALUE with Crystal Ball™ software, which operates with MS Excel [3].

Several input parameters are selected for simulation, and the probability distribution is defined. After the random sampling for each parameter, an economic evaluation is conducted at given times. The NPV and B/I ratio is calculated for each time. In this case, we use just two distribution functions: linear and triangle. Fig. 1 shows these two distributions. The linear distribution has the same probability within the range; the triangle distribution has a maximum probability for a median value and zero probability for a minimum value and a maximum value.



(a) Linear (b) Triangle

Fig. 1. Input Parameter Distribution

3.2 Discussion of Uncertainty Analysis

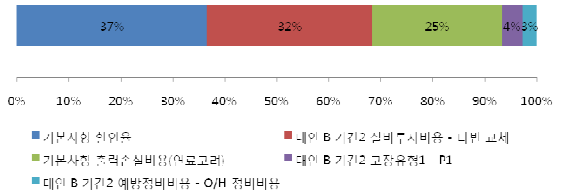
From the uncertainty analysis, we can get the distribution of the NPV and the B/I ratio of each

alternative. A deterministic economic evaluation yields only one result. However, the probabilistic economic evaluation result gives a range of values for the NPV, the B/I ratio, and the benefit of alternative. The scatter of the result values is closely related to the sensitivity index of the input parameters. These results are useful for assessing mid-term and long-term investment plans.

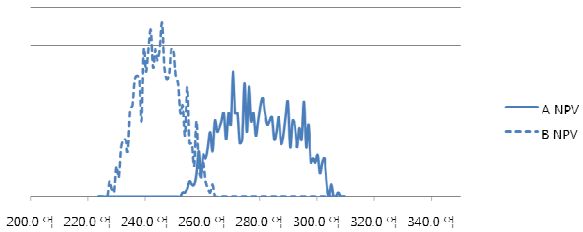
4. Economic Evaluation Tool

We developed the new economic evaluation tool based on the MS Excel Visual Basic Application which has a module for parameter sensitivity analysis and uncertainty analysis. In this program, a user can select a maximum five input parameters for sensitivity analysis and uncertainty analysis and determines the number of random sampling calculations. Fig. 2 shows the results of the sensitivity analysis and the uncertainty analysis. Alternative A is a plan for maintaining an as-is condition, alternative B is an investment plan. The uncertainty analysis confirms that there is a small probability of loss on the investment plan.

변수 민감도 평가						비교 대안	B
항목	구분	입력		출력(A안 대비 이득)		민감도 지수	
		값	변화율	값	변화율		
기본사항 할인율	하한	0.055	8%	₩2,545,694	4%	0.516	0.497
	중간	0.06	-	₩2,440,685	-	-	
	상한	0.065	8%	₩2,343,521	4%	0.478	
대안 B 기간2 설비투자비용 - 터빈 교체	하한	1400000	7%	₩2,370,189	3%	0.433	0.433
	중간	1500000	-	₩2,440,685	-	-	
	상한	1700000	13%	₩2,581,677	6%	0.433	
기본사항 출력손실비용(연료고려)	하한	37	8%	₩2,378,701	3%	0.339	0.339
	중간	40	-	₩2,440,685	-	-	
	상한	43	8%	₩2,502,670	3%	0.339	
대안 B 기간2 고장유형1 - P1	하한	0.04	20%	₩2,414,204	1%	0.054	0.054
	중간	0.05	-	₩2,440,685	-	-	
	상한	0.06	20%	₩2,467,166	1%	0.054	
대안 B 기간2 예방정비비용 - O/H 정비비용	하한	8000	20%	₩2,422,874	1%	0.036	0.036
	중간	10000	-	₩2,440,685	-	-	
	상한	15000	50%	₩2,485,212	2%	0.036	



(a) Sensitivity Analysis Result Table and Graph



(b) Uncertainty Analysis Result Graph (NPV Cost)

Fig. 2. Analysis Result for Sample Case

5. Results and Discussion

The parameter sensitivity analysis shows the degree of impact that an input parameter has on the economic evaluation results, and the uncertainty analysis (or random sampling analysis) shows the distribution of the economic evaluation results. Our new economic evaluation tool was developed with these functions, and the results will be useful for assessing the mid-term and long-term investment plans.

Economic evaluation is the one of the most useful tools for providing a quantitative value for an investment plan. Needless to say, the reliability of economic evaluation results is closely related to the reliability of the input parameter values. Reasonable and reliable input values must therefore be used. For the same reason, the distribution range of input values is also important for uncertainty analysis.

REFERENCES

[1] LcmVALUE, EPRI, Project No. 6118, 2002
[2] LCM Planning Tool (LcmPLATO), EPRI, 1006686, 2002
[3] LCM Economic Tools Demonstration, EPRI, 1007931, 2004