Sensitivity Analysis of Financial Feasibility Factors in Nuclear Power Plant Projects

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1. Introduction

Many papers have argued over the economic efficiency and effectiveness of nuclear energy since the Fukushima disaster. Some countries are adapting nuclear phase-out policy to stop utilizing nuclear generation. However, other countries, especially developing ones, are still willing to construct nuclear power plants (NPPs) in the future to meet their electricity demand which is expected to grow rapidly. Likewise, under these contradicted and complicated circumstances, it is important to precisely calculate the economic value of nuclear generation to help decide whether to invest or not.

Most of the articles have analyzed this economic issue using the Levelized costs of electricity (LCOE) terminology. LCOE is simple and useful in that it considers time effect and reflects the discount rate on the overnight capital cost factor. So, the LCOE concept is a very widespread indicator in that it can easily compare with different lifecycle energy plants [1]. Despite its worldwide and traditional utilization, LCOE equation itself is not the perfect approach from the financial perspective. First, LCOE only deals with the costs which exclude the concept of the profit. Even though LCOE provides the minimum required tariff to recover the total costs, LCOE cannot reflect well that tariff growth rate effects on the discount rate impact. Second, LCOE simply assumes that the loan payback period is same as the lifecycle operation period. In reality, the payback period of NPP projects is far shorter than the lifecycle period which lasts up to 60 years. Last, the same discount rate is usually applied for comparing the LCOE of each energy source. However, the discount rates can vary among different kinds of generation sources even in the same country.

The financial feasibility analysis considers not only cost but also profit, and distinguishes the operation period from the payback period. In addition, the financial model calculates the appropriate discount rate considering the weighted average capital cost (WACC).In addition, the financial value is represented with the financial indicators like Internal Rate of return (IRR), Return on Equity (ROE), Debt Service Coverage Ratio (DSCR), and net profit. This paper analyzes which financial factor is more important and sensitive to yield profitable nuclear projects using Monte-Carlo simulation.

2. Background

2.1 LCOE calculation

LCOE value is usually calculated as follows: total life time cost divided by total life time energy production. Many variable inputs are considered in the calculation of LCOE value. Key inputs include capital costs, fuel costs, capacity factor, and fixed and variable operations and maintenance costs. Among these factors, huge capital cost affects LCOE value of nuclear energy the most. Long construction period also has a high influence. However, despite having a high initial capital cost with a long construction period, NPPs are capable of generating electricity for a long time with their relatively high capacity factor [2]. At present, renewable energies have relatively higher LCOEs than the established power generation methods because of their immaturity and low capacity factor [3].

2.2 Financial Feasibility Analysis

There are various financial models of nuclear power plants and those have changed significantly over the last decades. Especially, financial models follow trends that change from government financing to private financing [4]. These changes have made financial results more important. Therefore, it is important to analyze precisely the financial factors which can have a huge influence on the financial values like IRR, ROE, DSCR, and net profit. Most of the factors are utilized again in the financial model same as in the LCOE model: construction period, construction cost, operation period, and operation cost. Some financial feasibility factors like power price (tariff), power price growth, payback period and discount rate based on the WACC are introduced in the financial model.

3. Methodology

3.1 Financial Feasibility factors

It is necessary to use many input data to derive financial cash flow. Financial feasibility factors are mentioned in section *2.2*. This study uses construction period, construction cost, inflation rates in both exporting and importing countries, and power price growth rate which are selected as the crucial financial factors affecting the most important financial indicators; IRR.

Table 1: Major differences between LCOE calculation and Financial model apprach

Characteristics	LCOE	Financial model
Tariff growth	Not consider	Consider
Payback period	lifecycle period	Actual payback period
Discount rate	based on Debt	Based on WACC

3.2 Sensitivity Analysis using Monte Carlo Simulation

Financial Sensitivity Analysis is the analysis of the effect of the financial factors on financial values like IRR when other conditions remain constant. This analysis helps to prioritize and manage the factors that impact on the project's financial success using Monte Carlo simulation. Monte Carlo simulation is the most widely used simulation tool based on random generation and probabilistic distribution. This Simulation is a kind of simulation technique and also a relatively simple and established technique for including uncertainty in quantitative models [3].

3.3 Case Study

Project A is provided as a case study here. Country B is supposed to construct four units (total 4800MW) of nuclear power plants in country C in 10 years. It is estimated around $20 billion and plants are supposed to operate for 60 years. It is to be analyzed to find the financial feasibility with various input factors such as construction period, construction cost, operation period, operation cost, power production, power price, and etc. Also, some variations are utilized to find the sensitivity of each factor such as cost escalation, time overrun, debt to equity ratio, and availability with each distribution using Monte Carlo Simulation.

4. Results and Discussion

Here, IRR which is one of the important financial indicators is being analyzed by using Monte Carlo Simulation. Five input data are represented in figure 1 below. In this case, input data are construction period (yellow line), construction cost (green line), inflation rate in importing country (purple line), inflation rate in exporting country (blue line), and power price growth rate (red line). The gradient of each factor shows how much it reacts sensitively to the IRR. It is shown that power price growth rate (red line) affects IRR the most as its gradient varies the most. This means that power price growth rate should be managed well in order to get financial results. The blue line which means inflation rate in exporting country also should be well taken care of.

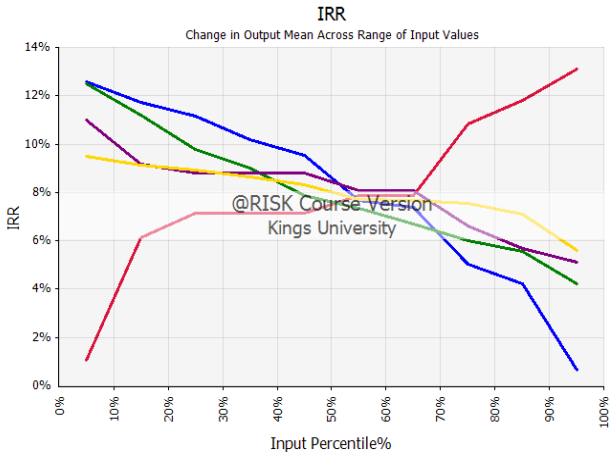

Fig 1: IRR sensitivity analysis of Project A[5]

5. Conclusions

LCOE has been used to judge the economic competitiveness and find the grid parity among different generation technologies. Energy investors are using the LCOE as a key indicator to compare the unit cost of each other, especially in the development phase.

However, LCOE approach tends to simplify the actually complicated financing world. As the project development, the more accurate variables should be used. So, this paper analyzes the more realistic financial model by considering the tariff growth rate, actual loan payback period and appropriate discount rate. The discount rate might be reduced after in the operation phase.

Financial feasibility and sensitivity analysis help the investors determine which factors to prioritize by finding out how much they affect the values of the financial indicators. This paper focuses on the effects of some critical financial factors on IRR. The further sensitivity analysis will include various variables such as ROE, tariff growth rate, payback period and DSCR.

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