ECO-FRIENDLY ENERGY SYSTEM DESIGN FOR AN ISOLATED ISLAND : A CASE STUDY OF GASADO, KOREA

Joyoung Kwon, Hanyang University, +82 10-2100-7663, jykwon01@hanyang.ac.kr
Juhan Kim, Hanyang University, +82 10 4336 1596, juhankim@hanyang.ac.kr
Jinsoo Kim, Hanyang University, +82-2-2220-2241, jinsookim@hanyang.ac.kr

Overview

An eco-friendly energy-isolated island system is designed to supply electricity using a renewable energy source if power supply is not stable. A microgrid for isolated island construction refers to a small and self-supporting grid that produces and supplies electricity through an energy source. The main advantages include the self-sufficiency of power and the use of storage systems to ensure that supplies are safe and stable. Recently, the use of microgrid projects is expanding globally. In particular, South Korea is gradually expanding its isolated island business through microgrid construction in in accordance with current government's policy of energy conversion and reducing the dependence on coal and nuclear energy. However, when analyzing the economic feasibility with existing isolated island models, the following problem is revealed: the power amount of renewable energy actually used and the economic benefit are low.

In this study, we constructed an isolated island model that is newly optimized based on renewable energy sources, including the Energy Storage System(ESS) in the Jindo Gasado Island area in Korea. First, we investigated the regional and environmental characteristics of the area, the power load pattern, and the generator specifications of the renewable energy generation system linked with the ESS. Also, the economics and feasibility evaluation were performed quantitatively based on the simulation of each generation source and the operating costs during the project period. Currently, the existing independent island model operates a renewable energy generation plant and a diesel generation plant together. However, the newly constructed isolated island model is constructed to enable the supply of power using 100% of the renewable energy source. In addition, the effect of reducing greenhouse gases was confirmed by considering the emission of air pollutants such as carbon dioxide, as a cost.

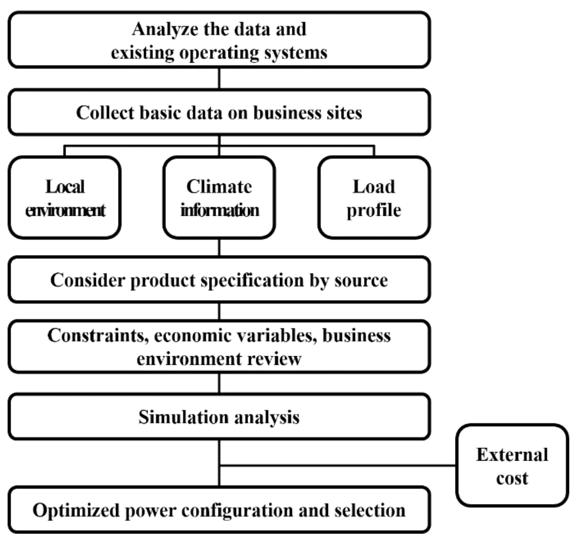

Figure 1. Energy-isolated island generation mix framework

Methods

First, the project cost minimization model $Min(NPC_t)$ represents the value at which the net present cost is minimized by applying the discount rate to all costs incurred during the project period. The main purpose of this study is to derive the result of the lowest net present cost considering electric power the load and cost.

$$Min(NPC_t) = Min \sum_{i=1}^{n} \frac{K_{t+i}+RP_{t+i}+OM_{t+i}}{(1+r)^i} \quad (1)$$

Second, the unit cost of electricity represents the average cost per kWh of electric power produced by the power generation system. The total cost of operation or maintenance and the annualized total power load supply can be used to calculate the following:

$$COE = \frac{C_{ann,tot}}{E_{served}} \quad (2)$$

The HOMER program was used for simulation and optimization analysis. This program can be modeled with various generators, such as renewable energy, diesel generators and ESS. First, the simulation results show that the generation capacity and overall efficiency of each power source in different seasonally or hourly can be determined in detail. In the optimization analysis, the Net Present Cost(NPC) is calculated based on the simulation analysis of all of the costs of each generator under the project period. In detail, the results are presented as to cost summary, cash flow, electrical energy and emissions.

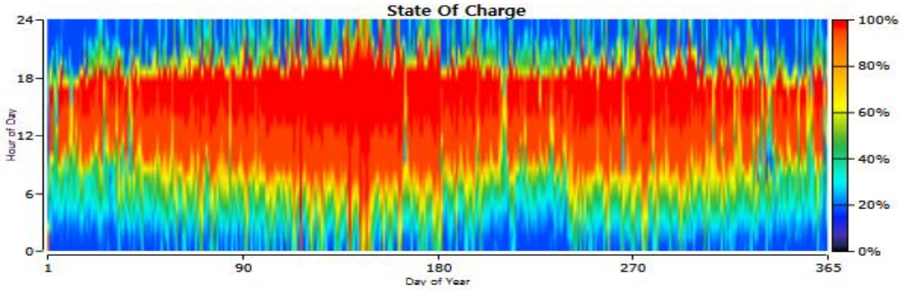

Figure 2. ESS charge & discharge simulation

Results

We compare and analyze the optimized isolated island model and the existing isolated island model.

Subsection	System Configuration
Case 1	Currently operated power generation system
Case 2	Existing power generation system + Photovoltaics
Case 3	Existing power generation system + Wind
Case 4	Existing power generation system + ESS

Table 1. Gasado power system configuration

Subsection	Case 1	Case 2	Case 3	Case 4
Unit Price (KRW/kW)	481.81	342.69	311.03	308.77
Operating cost (million KRW/kW)	380	108	110	109
Initial cost (million KRW/kW)	9,200	4,128	4,116	4,115
Renewable power generation (%)	65	100	100	100

Table 2. Analysis of economic results

The newly constructed power system model was confirmed to be more suitable through an economic evaluation. First, the cost of power generation, which is a measure of economic feasibility, a Case 1 was the highest with a value of 481.81won/kW, while in Cases 3 and 4, it was the lowest at about 310 won/kW. Therefore, if we add Case 3, wind power, among the constructed isolated island models, cost savings can be achieved, and the amount of power generation can be increased through renewable energy sources. Next, we consider the annual operating costs. In Case 1, the operating cost of a 100% diesel power generation system is reduced to 380 million won. In comparison with Case 1, the result of the new power generation system will reduce the cost to about 100 million won. Finally, it demonstrates a savings of about 85% from the annual operating cost of a diesel power generation system of 700 million won.

Conclusions

In this study, a new optimized island model was constructed by adding the renewable energy source and the ESS based on the Jindo Gasado island area in Korea. A comparison of the existing isolated island model and the optimized one shows that the generation of renewable energy is low and the economic cost is high. In conclusion, by reducing diesel power generation and increasing the proportion of renewable energy sources, it is expected that the system will be able to supply, consume, and store power using 100% eco-friendly energy as the overall power management system of Gasado. In addition, the company is also investigating ways to verify the suitability of the facility by utilizing an abandoned mine site.

References

A hadi, A., Kang, S. K and Lee, J. H., 2016, “A novel approach for optimal combination of wind, PV and energy storage system in diesel-free isolated communities”, Applied Energy, Vol. 170, pp. 101-115

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