Hybrid Power Plant System Analysis in Seruni Beach, Bantaeng District, South Sulawesi

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Abstract. Seruni Beach is one of the tourist attractions in Bantaeng Regency, South Sulawesi. As an area that has potential as a tourist place, it must be supported by adequate electricity supply. The electricity source in Seruni Beach is only supplied by the State or PLN power plants. To reduce the electricity supply from the National Electric Company, a hybrid power plant is designed that utilizes the potential of alternative energy sources in the form of wind and solar energy. The purpose of this study is to produce efficient solar and wind hybrid plants as a backup generator in supplying the loads that are around the coast. The study uses HOMER as an optimal generator determinant. The indicators are used as economic valuations, namely payback period (PP), net present value (NPV), net present cost (NPC), and cost of energy (COE). The study uses 2 schemes to calculate the indicators used. Scheme 1 only uses the grid as a supplier of electricity, and in scheme 2 uses wind turbines, solar panels, and grids. The results of this research are solar and wind power hybrids producing 390,620 kWh / year. Scheme 1 has a higher NPC value of Rp 4,632,183,000 while scheme 2 has an NPC value of Rp 2,555,496,645. The costs incurred by scheme 2 to produce electricity per kWh are smaller, namely Rp. 304,709 compared to the scheme 1 in the amount of Rp. 1467.28. in scheme 2, the NPV is positive in the amount of Rp. 1,037,919,493 and from the results of the calculation of the payback period, the time needed to recover the investment costs of solar and wind power plants is 5 years 10 months.

1. Introduction
Bantaeng is a district located in the province of South Sulawesi which has an area of 395.83 km². Bantaeng Regency is located in an area with a coast that has potential as an industrial and tourism area. As an area that has potential as a tourist place, it must be supported by a good supply of electricity. Electricity sources in Bantaeng regency are only supplied by the State or PLN power plants in the area even though the area has several beaches that can be used to build solar and wind power plants. Wind energy is an abundant resource available in nature as an alternative energy source that can be renewed (renewable energy) which can be used as a wind power plant. Likewise with solar power plants that utilize solar thermal energy, but the use of renewable natural resources is still very minimal in its use. PT PLN (Persero) stated that in 2010-2019 it was estimated that electricity needs reached 55,000 MW, so the average increase was 5,500 MW. Of the total 32,000 MW of power, (57%) is built by PLN, the remaining 23,500 MW will be built by the private sector [1]. From these data it can be concluded that electricity generation, especially in Indonesia, still relies on PLN which uses non-renewable energy as its energy source and still lacks utilization of renewable energy sources.

Bantaeng Regency, which is located on the coast, is very suitable to develop hybrid power plants because it has the potential of natural resources in the form of solar and wind heat energy. With the availability of these hybrid power plants, it is expected to become a backup power plant in the area. The
design is done using Homer software as software that designs, tests, and simulates the results of the design.

2. Basic Theory

2.1. Solar Power Plant

Hybrid power plants are power generation systems that have two or more integrated ones. Hybrid plants consist of two plants, namely renewable and conventional power plants or consist of a combination of renewable power plants. The purpose of a hybrid system is to get efficiency or use alternative energy as a source of electrical energy. Alternative energy sources commonly used in designing hybrid systems use solar energy using photovoltaic (PV) and wind energy using wind turbines as generators. [2]

2.2. Grid Tie Inverter

Grid tie inverter or commonly known as synchronous inverter is an inverter that functions to convert DC electric cur-rent into AC current [3]. The inverter converts the DC current to a component such as a solar cell, the battery becomes an AC. This grid inverter can not stand alone and must be connected to the PLN. The advantages of kWh obtained from PLTS from the presence of this inverter can be channelled to the PLN and instead PLN pays to the PLTS provider. There are two systems that are used on the Grid Tie System, namely the off grid and on grid systems that have their respective differences. The difference between off grid and on grid is as follows:

- Off Grid System
  Off grid system is a generating system that can only produce electricity by relying on energy sources from the plant that is owned as its main energy. Off grid system is used in areas that have not been reached by PLN electricity. Examples of off grid systems are SHS (Solar Home System).

- On Grid System
  On grid system is a generating system that generates electricity from a generator owned, the difference from an off grid sys-tem is an on grid system connected to the PLN electricity net-work. The purpose of this system is to reduce electricity consumption from PLN and reduce electricity bills.

2.3. Payback Period

Payback period is the time needed to return the investment costs of the project. To get the payback period value by dividing the investment costs with the income generated by the generator in a year [4]. The payback period can be calculated using the following equation (1):

\[
\text{Payback Period} (t) = \frac{\text{investment cost}}{\text{income per year}}
\]  

Payback period can be said to be feasible if the payback time for investment costs is smaller than the time the project is done.

2.4. Net Present Value

Net Present Value is income earned in the future whose interest has been paid at the beginning or discount. The data required to find the value of NPV in the form of investment costs, maintenance and repairs, and the income derived from plants are designed. The Net Present Value can be calculated using equation (2):

\[
\text{NPV} = \frac{R_t}{(1+i)^t}
\]

Where:

i = bank interest rate

\(t\) = year period

R\(_t\) = net income in time t
2.5. Cost of Energy

Cost of Energy is the expenditure cost per kWh of electrical energy produced by the generator used. COE can be calculated by dividing the total plant cost per year by the total energy load per year (kWh). COE can be calculated using the following equation (3):

$$\text{COE} = \frac{TAC}{E_{\text{tot.served}}}$$  \hspace{1cm} (3)

Where:
- $E_{\text{tot.served}}$ = total annual energy used to serve the load (kWh)
- TAC = total annualized cost incurred for hybrid generation.

3. Research Method
3.1. Research Flow

The flow chart as shown in Figure 1 is the stage carried out during the study. The steps taken are:
- The literature study is looking for and studying various literatures that discuss topics around the research conducted.
- Data retrieval is to collect data to be used during research, in the form of solar radiation data, wind speed data, and electrical load data on Seruni Beach.
- Simulate data that has been taken in the HOMER software to get optimal results. Then do the preparation of the report.
- Research completed.

3.2. Design of Solar and Wind Hybrid Power Generation Systems Using HOMER

The simulation that will be carried out uses HOMER as a software, while the components used are photovoltaic, batteries, converters, and wind turbines. The simulation is divided into 2 parts as shown in Figure 2 and Figure 3, first only using the grid as electricity supply then in the second part using a grid accompanied by wind and solar power plants.
4. Results and Discussion
The design of solar and wind power hybrid plants in this study uses homer as software. In this study, grids sourced from PLN will be compared to hybrid plants that are designed, with the aim of looking at the benefits of the generator designed, namely from the economic side, the energy produced, and the influence on the environment. Timeline of projects designed at HOMER for 25 operational years.

4.1. Analysis of the Scheme Plant 1

Table 1. Total Energy Used in a Year and Its Parameter

| Parameter                  | Amounts          |
|----------------------------|------------------|
| \(\text{Net Present Cost}\) | 4,632,183,000   |
| \(\text{Cost Of Energy}\)  | 1,467,28         |
| Energy consumption (kWh/tahun) | 142,668         |
| \(\text{Renewable Penetration}\) | 0%               |

The Table 1 shows the total use of electrical energy used in a year. The use of electrical energy comes from the load used which is equal to 142,668 kWh/year. The cost of energy calculated at HOMER in scheme 1 is 1,427.28.

4.2. Result Calculation of Net Present Cost Scheme 1

The net present cost value obtained from the results of calculations performed by HOMER as shown in Figure 4 is 4,632,183,000. In addition to HOMER calculations, NPC values can also be calculated using equations

\[
NPC = 4,632,183,177 + 0 + 0 + 0 + 0
\]

\[
NPC = Rp 4,632,183,177
\]
4.3. Result Calculation of Cost of Energy Scheme 1

| Table 2. Energy Consumption and Total Annual Cost |
|--------------------------------------------------|
| Parameter                                      | Amounts       |
| Energy Consumption                             | 142.668 kWh/tahun |
| Total Annualized Cost                          | Rp 209,333,946 |

The Table 2 shows data on electricity consumption and total annualized costs. COE values can also be calculated using equations (3).

\[
COE = \frac{\text{Rp 209,333,946}}{142,668 \text{ kWh}} \quad \text{COE} = \text{Rp 1,467.28/kWh}
\]

4.4. Result Calculation of Payback Period Scheme 2

The electricity selling price for the region in South Sulawesi is based on the 2017 Minister of Energy and Mineral Resources regulation of Rp 974.00 [14], the total power generated by the plant is 438,073 kWh / year. So that the annual income generated by the generator is:

\[
\text{Rp 974} \times 438,073 \text{ kWh} = 426,683,102.00, \text{– year}
\]

The investment cost for designing a hybrid power plant is Rp 2,555,496,645, - so the payback period is:

\[
\text{Payback Period (t)} = \frac{\text{Rp 2,555,496.645}}{426,683.102} = 5.98 \text{ years} = 5 \text{ years} 10 \text{ months}
\]

From the calculation above, to restore the capital cost for the generation of hybrid electricity of solar and wind power it takes 5 years and 10 months.

4.5. Result Calculation of Net Present Value Scheme 2

Net present value can be calculated by calculating income and costs discounted by 11% (interest rate) for 25 years [5]. Net present value can be calculated using equation (2):

\[
NPV = \frac{R_t}{(1 + i)^t}
\]

So that the NPV value can be seen at the Table 3.

| Table 3. Net Present Value of Hybrid Solar Wind Plant |
|----------------------------------------------------|
| Year | Cash in       | Bank interest | Cash value               |
|------|---------------|---------------|--------------------------|
| 0    | Rp 2,555.496.645 | 1,00           | Rp 2,555.496.645         |
| 1    | Rp 426,683.102   | 1,11           | Rp 384,399.191           |
| 2    | Rp 426,683.102   | 1,23           | Rp 346,305.577,5         |
| 3    | Rp 426,683.102   | 1,37           | Rp 311,987.006,7         |
| 4    | Rp 426,683.102   | 1,52           | Rp 281,069.375,4         |
| 5    | Rp 426,683.102   | 1,69           | Rp 253,215.633,5         |
| 6    | Rp 426,683.102   | 1,87           | Rp 228,122.210,4         |
| 7    | Rp 426,683.102   | 2,08           | Rp 205,515.504,9         |
| 8    | Rp 426,683.102   | 2,30           | Rp 185,149.103,5         |
Table 3 above shows the net present value of Rp. 1,037,919,493 (positive value), it can be concluded that the capital of hybrid power plants is accepted and can be done.

5. Conclusion
Wind and solar power hybrid power plants have the potential to be built because natural and wind resources have the potential to be used. In addition, solar and wind power hybrids that have a capacity of 24.8 kW can produce electrical energy of 438,073 kWh/year.

The cost of energy in scheme 2 has a smaller value that is equal to 79.27% of the value of scheme 1 because in the scheme 2 the energy produced mostly comes from renewable energy generation.

In scheme 2, to return the investment value used it takes 5 years 10 months, but the NPV value of the generator is positive, which means that the value of the investment has benefits and the construction of the plant can be carried out.

6. References
[1] K. Daljeet and P. S. Cheema, “Software Tools for Analyzing the Hybrid Renewable Energy Sources:-A Review,” Int. Conf. Inven. Syst. Control, pp. 1–4, 2016.
[2] H. Mubarok, “Optimal specification analysis of hybrid-PV-battery-diesel power generation based on electrical outage cost as an industrial reserve power,” IEEE, vol. pp. 253–257, October 2017, International Seminar on Application for Technology of Information and Communication (isemantic) Semarang, 2017.
[3] M. H. Nehrir et al., “A review of hybrid renewable/alternative energy systems for electric power generation: Configurations, control, and applications,” IEEE Trans. Sustain. Energy, vol. 2, no. 4, pp. 392–403, 2011.
[4] A. K. Pradhan, S. K. Kar, and M. K. Mohanty, “Off-Grid Renewable Hybrid Power Generation System for a Public Health Centre in Rural Village,” Int. J. Renew. Energy Res., vol. 6, no. 1, pp. 282–288, 2016.
[5] H. Mubarok, “Economic Studies of Wind Turbine Diesel Hybrid Power Generation System (Case study at Queen of the South Beach Resort Hotel, Yogyakarta, Indonesia.” IEEE, September 2018, International Seminar on Application for Technology of Information and Communication
(iSemantic) Semarang, 2018.

[6] Aziz Saleh Ali dkk. “Feasibility Analysis Of PV/Wind/Battery Hybrid Power Generation”, A Case Study, *International Journal of Renewable Energy Research*, Vol.8.No.2.2018.

[7] Betha Divya dkk. “Design and Control of Grid Connected PV/Wind Hybrid System Using 3 Level VSC”, *Publisher*: IEEE, *International Advance Computing Conference (IACC)*, India.2017.

[8] Foster R., Ghassemi M., Cota A. “Solar Energy: Renewable Energy and The Environment”, Boca Raton, FL : CRC Press, Taylor & Francis Group, New York. 2010.

[9] Tan D., Seng Ang K. “Handbook For Solar Photovoltaic (PV) System”, Published by Energy Market Authority, Building and Construction Authority, Singapura, ISBN: 978-981-08-4462-2, Hal. 4-7. 2011.

[10] Wei Tong. “Wind Power Generation and Wind Turbine Design”, Kollmorgen Corp., USA, Published by WIT Press Southampton, Boston, Hal. 15-16. 2010.

[11] Lambert T., Gilman P., Lilienthal P. “Micropower System Modeling With Homer”, *Integration Of Alternative Sources Of Energi, by Felix A., Farret and M. Godoy Simoes.*, John Wiley and Sons, Inc, Hal. 379-397. 2006.