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Utilization Photovoltaic for Electrical Energy Needs in Kelapan Island

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Abstract. Kelapan Island is one of the outermost islands in the Bangka Belitung Province. With a total of 30 households consisting of 120 people, electricity is currently from diesel generators. The dominant electrical equipment used on Kelapan Island are lights, televisions, fans, irons also several units of refrigerators and washing machines. For reducing the use of fossil energy, electrical energy sources are modeled for supply using a photovoltaic system. The average amount of electricity needed per house is 290.9 W, so the amount of power required for 4 hours at night is 34.908 kWh. The photovoltaic system will be modeled in 2 stages, centralized photovoltaic and photovoltaic at each resident's house. The photovoltaic system that is installing in each residential house requires four units of 100 Wp solar panels, six units of 100 Ah batteries, 1 unit of a 400-watt inverter, and four units of solar charger controllers. Whereas for the centralized photovoltaic system model requires 97 units of 100 Wp solar panels, 160 units of 100 Ah batteries, 25 units of 400-watt inverters and 108 units of solar charger controllers.

1. Introduction

A lot of utilization of the photovoltaic system as a source of electrical energy for the outermost villages or outer islands far from the main electricity network [1-7]. Kelapan Island is one island in Bangka Belitung that is not connected with the main electricity grid yet has the potential of photovoltaic system utilization to supply electricity needs of the inhabitants. Kelapan island is located in the district of South Bangka, Bangka Belitung Islands Province, as can be seen in figure 1. Demographically, the Kelapan island has 30 households. Most of the people work as fishermen. Electricity demand will increase, along with population growth every year [8]. Currently, Kelapan island's electricity needs are supplied by diesel generators that are operated for 4 hours per day from 06.00 to 10.00 pm due to the operational costs. Utilization of photovoltaic system is an alternative because Bangka Belitung Islands Province is an area with solar radiation for most of the year with solar radiation 4.95 kWh/m^2 [9]. Also, it would be more effective and efficient for small islands to use existing energy sources to meet electricity energy needs compared to connecting the islands to the primary grid of electricity systems.

Several studies related to the use of photovoltaics in Bangka Belitung Island Province have implemented to optimize the use of the sun as a source of renewable energy [9-10]. In the Regional Energy General Plan for the Bangka Belitung Islands Province, solar energy is also used as an option for electrical energy sources for reducing the use of fossil energy and fulfill the electrical energy needs in the outer island.

Figure 1. Location of Kelapan island [11]

2. Method

For modeling photovoltaic as the source of electrical energy in Kelapan Island, there are some following steps to ensure the modeling system based on electrical energy needs

1. Collecting the data profile of residents in Kelapan island, including electrical energy consumption.
2. Design of stand-alone and centralized photovoltaic system and calculate the capacity and number of components to be used.
3. Calculate the estimated cost for the photovoltaic system and compare the two designs by considering data on electricity load and solar radiation on Kelapan island.

3. Result and Discussion

Currently, the power generation system on Kelapan island uses a power source generated by diesel generators. Each resident's house on Kelapan island has one generator set. It means that one generator set only serves for one resident's home. The duration of the generator's operation is 4 hours per day with fuel consumption of 2 liters per day which operates 4 hours a day starting from 06.00 until 10.00 p.m

From data on figure 2, the electrical power supplied to the community on Kelapan island is 8.727 kW with an average electric power of 290.9 watts per house operating for 4 hours/day. The average value of daily electricity consumption on Kelapan island is 34.908 kWh.

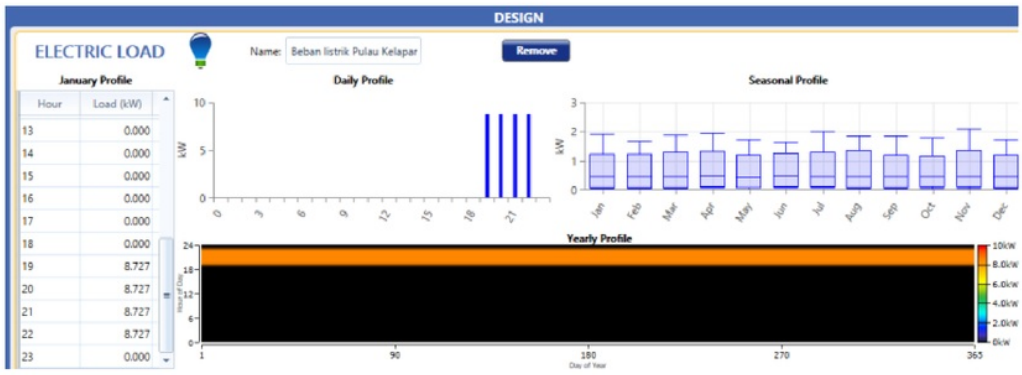

Figure 2. Load profile in Kelapan island [12]

Table 1. Daily average temperature and percentage of sunlight in Pangkalpinang [13]

No.	Periode	Percentage of sunlight(%)	Temperature (°C)
1	January	43.9	27.2
2	February	35.2	26.6
3	March	42.9	27
4	April	47.4	27.6
5	May	47	27.8
6	June	51.2	27.5
7	July	57.1	27.7
8	August	55	27.8
9	September	52.8	27.3
10	October	38.9	26.9
11	November	38.6	26.9
12	December	24.9	26.9

Table 2. Daily solar irradiation in Kelapan island [13]

No.	Periode	Daily solar radiation (kWh/m²/day)
1	January	4.28
2	February	4.79
3	March	4.68
4	April	4.6
5	May	4.43
6	June	4.42
7	July	4.49
8	August	4.89
9	September	4.96
10	October	4.66
11	November	4.25
12	December	3.99

Based on data in Table 1, the average daily temperature of Pangkalpinang is 27.3 ºC, with the percentage of solar irradiation time of 44.58%. It means that the maximum sun exposure time is 5.5 hours a day. Also, from Table 2, the average daily solar irradiation on Kelapan island is 4.54 kWh/m^2/day.

3.1. Stand-alone photovoltaic system

In this system, photovoltaic is installed in each resident's house to supply the electricity in the home. Electrical energy can be connected directly to the load or stored first in the battery [14]. To determine the capacity of components in a stand-alone photovoltaic system, we must determine the average electricity load per house on the Kelapan island. The average electricity load per house on Kelapan

island is 290.9 watts, so the electricity consumption for 4 hours is 1.163 kWh. The components for stand-alone photovoltaic consist of four solar panels with a capacity of 100 Wp, six battery units with a capacity of 100 Ah, one inverter with a maximum power capacity of 400 watts and four units of solar charger controller with a current capacity of 30 A. The total estimated cost for constructing stand-alone photovoltaic systems for all houses in Kelapan island is Rp. 588.7 million.

3.2. Centralized photovoltaic system

A centralized photovoltaic system to serve loads by placing panels centrally in one place. In a centralized photovoltaic system, the electricity load served includes all customers in a place. It means that in this system, capacity is large enough so that it requires a particular area of land as a place to put panels. For a centralized system on Kelapan Island consist of 97 units of solar panels with a capacity of 100 Wp, 160 units of necessary battery with a capacity of 100 Ah, 25 units of an inverter, and 108 units of solar charger controller with the current capacity of 30 A. The total estimated cost for constructing centralized photovoltaic system in Kelapan island is Rp. 528.25 million.

4. Conclusion

The total electric power needed by the community in Kelapan Island is 8.727 kW with electricity consumption of 34.908 kWh. The capacity and number of photovoltaic components required to meet electricity needs in Kelapan Island require four units of 100 Wp solar panels, six units of 100 Ah batteries, 1 unit of 400 watts of the inverter, and four units of solar charger controller for a stand-alone photovoltaic system. For centralized photovoltaic system requires 97 units of 100 Wp solar panels, 160 units of 100 Ah batteries, 25 units of 400-watt inverters, and 108 units of solar charger controllers.

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