

Design of Photovoltaic as Energy Source at Government Office in Pangkalpinang

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Abstract

In the regulation of the general energy plan for the Bangka Belitung region, it is targeted that the total use of new and renewable energy will reach 17.21% in 2025 and 30.97% in 2050. This, of course, requires a measurable implementation to achieve this. In this regard, a photovoltaic design was carried out as a source of electrical energy in one of the government offices in Pangkalpinang. This office's daily demand for electrical energy is 78.79 kWh, with an average solar irradiance of 487.51 W/m² and a measured ambient temperature of 26° – 33.3° C. The modeling is carried out using three types of photovoltaic panels, a namely polycrystalline, monocrystalline and thin film with a supply power is combined with a source from PLN and 100% photovoltaic

Keywords: renewable energy, photovoltaic, solar irradiance, ambient temperature

1. Introduction

Pangkalpinang is the capital of the Bangka Belitung Islands Province, with a population of 212.700 people in 2019, equal to 14.29% of the total population of the Bangka Belitung Islands Province [1]. To meet the electrical energy needs in Pangkalpinang itself, in 2020, PLN Bangka Belitung produces 480671.609 GWh from several types of existing power plants, including steam gas power plants and diesel power plants.

In addition to the use of fossil-based energy, several new renewable energy sources have also been developed, both owned by PLN Bangka Belitung or private. Including 1.41% sourced from biomass energy, 1.66% sourced from biogas, 1.77% sourced from vegetable CPO = 1.77% and 0.05% sourced from solar energy [2].

The development of new and renewable energy is in line with the Regional General Energy Plan of the Bangka Belitung Islands Province policy, which targets that in 2025, the new renewable energy mix will reach 17.21%, and in 2050 it will reach 30.97% [3]. The target set has a chance to be achieved because it has become a national achievement target, including the State-Owned Utility's 2019-2028 Electricity Supply Business Plan [4] by taking into account various factors in its preparation [5,6].

Several studies in Bangka Belitung related to the development of new energy have been carried out related to renewable energy [7] including solar energy [8-11], biomass energy [12,13], marine energy [14], and wind energy [15].

In this regard, a photovoltaic design will be carried out as a source of electrical energy in the city of Pangkalpinang as a way to increase new energy from the government sector.

2. Materials and Methods

This research went through several stages to obtain research supporting data, namely:

1. Making a plan of the research site-building
2. Measurement of solar irradiance at the study site using a solar meter as shown in figure 1
3. Measurement of temperature at the research site using a thermometer as shown in figure 2
4. Counting the number of electrical equipment used and their specifications
5. Get the amount of rupiah for electricity bill payments to support the amount of energy used in the last year
6. Design using three types of photovoltaic; polycrystalline, monocrystalline, and thin-film with several loading scenarios.



Figure 1. Solar irradiance measurement



Figure 2. Ambient temperature measurement

3. Results and Discussions

This research was conducted at the social service office of Pangkalpinang city, one of the organizations that directly serve the community in the Pangkalpinang city government. This office building only consists of 1 (one) floor with an area

of 700 m² with average monthly electricity consumption of 1666 – 2523 kWh.

Figure 3 is the result of measuring solar irradiance at the location measured using a solar meter. The measurement results show that the average solar irradiance is 487.51 W/m².

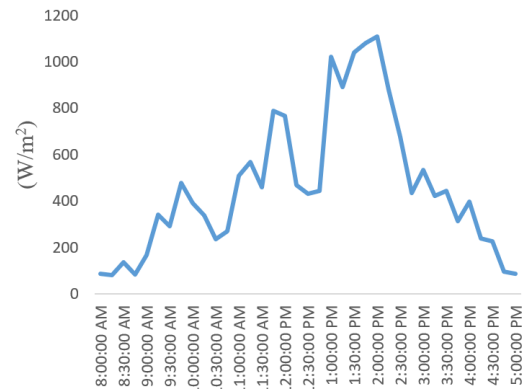


Figure 3. A solar irradiance measurement result

Figure 4 is the average ambient temperature at the research site whose measurements were made from 08.00 a.m – 05.00 p.m. The ambient temperature ranged from 26° – 33.3° C.

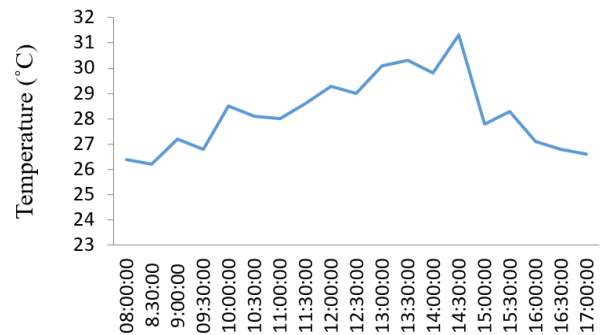


Figure 4. Temperature measurement result

This study has been modeled and carried out with several scenarios so that photovoltaic can be an option as a source of electrical energy in this office. The goal is that the target for the energy mix sourced from new and renewable energy can be increased immediately, with the government sector as an example.

This modeling is carried out in 4 scenarios while still guided by the fulfillment of daily electrical energy in the office. The measured daily electrical load of all existing equipment is 78.79 kWh.

Table 1. Scheme 50 % supply from PLN and 50% from Solar PV

Type of PV	Monocrystalline	Polycrystalline	Thin-film
PV Area (m ²)	480875	567432	515848
P (Wp)	90789	90789	90789
Number of PV (Unit)	454	454	454
V _{mpp} (Volt)	8172	8172	4086
I _{mpp} (Ampere)	11.12	11.12	22.2
P _{mpp} (Watt)	90872	90872	90709
Energy (Wh/day)	39430	39430	35781
Battery capacity (Ah)	11777	11777	10687
Number of battery (Unit)	79	79	72
Capacity of charger controller (Ampere)	0.65	0.65	0.65
Number of charger controller (Unit)	1	1	1
Capacity of Inverter (Watt)	5343	5343	5343
Number of Inverter (Unit)	1	1	1

Table 2. Scheme 70 % supply from PLN and 30% from Solar PV

Type of solar PV	Monocrystalline	Polycrystalline	Thin-film
PV Area (m ²)	961750	1134860	1031690
P (Wp)	181578	181157	181577
Number of PV (Unit)	908	908	908
V _{mpp} (Volt)	8172	8172	8172
I _{mpp} (Ampere)	22.24	22.24	22.2
P _{mpp} (Watt)	181745	181745	181418
Energy (Wh/day)	78862	78862	78720
Battery capacity (Ah)	23544	23554	23512
Number of battery (Unit)	158	157	157
Capacity of charger controller (Ampere)	0.65	0.65	0.65
Number of charger controllers (Unit)	1	1	1
The capacity of Inverter (Watt)	5343	5343	5343
Number of Inverters (Unit)	1	1	1

Table 3. Scheme 30 % supply from PLN and 70% from Solar PV

Type of PV	Monocrystalline	Polycrystalline	Thin-film
PV Area (m ²)	673225	794406	722187
P (Wp)	127104	127104	127104
Number of PV (Unit)	636	636	636
V _{mpp} (Volt)	3816	3816	3816
I _{mpp} (Ampere)	33.36	33.36	33.36
P _{mpp} (Watt)	127301	127301	127301
Energy (Wh/day)	55238	55238	55139
Battery capacity (Ah)	16498	16595	16469
Number of battery (Unit)	110	111	110
The capacity of charger controller (Ampere)	1.4	1.4	1.4
Number of charger controllers (Unit)	1	1	1
The capacity of Inverter (Watt)	5343	5343	5343
Number of Inverters (Unit)	1	1	1

Table 4. Scheme 100% from Solar PV

Type of PV	Monocrystalline	Polycrystalline	Thin-film
PV Area (m ²)	288964	340978	309980
P (Wp)	54556	54556	54556
Number of PV (Unit)	273	273	273
V _{mpp} (Volt)	3276	3276	1638
I _{mpp} (Ampere)	16.68	16.68	33.3
P _{mpp} (Watt)	54643	54643	54545
Energy (Wh/day)	23710	23710	23667
Battery capacity (Ah)	7081	7081	7068
Number of battery (Unit)	48	47	48
The capacity of charger controller (Ampere)	1.63	1.63	3.26
Number of charger controllers (Unit)	1	1	1
The capacity of Inverter (Watt)	5343	5343	5343
Number of Inverters (Unit)	1	1	1

The modeling scenarios are; (a) 50% power supply from PLN, and 50% power supply from photovoltaic both from the polycrystalline, monocrystalline, and thin film as shown in table 1,

(b) 70% power supply from PLN and 30% supply from photovoltaic both from the polycrystalline, monocrystalline and thin film as in table 2 (c) 30% of the power supply from PLN and 70% of the power supply from photovoltaic both from polycrystalline, monocrystalline and thin films as in table 3 and (d) 100% of the power supply comes from photovoltaic both from polycrystalline, monocrystalline and thin films as in table 4.

From table 1, it can be seen that using a 200 Wp photovoltaic panel, photovoltaic will supply 50% of the electrical energy requirement, which is 39.43 kWh/day. Meanwhile, in table 2, photovoltaic supplies 30% of the electrical energy requirement, 23.71 kWh/day. Then in table 3, it can be seen that 70% of electrical energy is supplied from photovoltaic, which is 55.238 kWh/day. Then in table 4, if 100% photovoltaic is used, the amount of electrical energy produced is 78.862 kWh/day.

4. Conclusion

This research focuses on designing photovoltaic as a new renewable energy source in the government sector to support the target of a new renewable energy mix. The daily electrical energy requirement measured at the Pangkalpinang city social service office is 78.79 kWh. The modeling scenario uses four models of combined power supply from PLN and photovoltaic. This design also compares three types of photovoltaic; polycrystalline, monocrystalline, and thin-film types.

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