Design and Construction of A 2X550 WP Solar Power Plant as A Source of Energy for The Main Procurement Motor for Training Ships

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Abstract. The development of the utilization of electrical energy sourced from the sun is currently experiencing very rapid development. The use of electrical energy sourced from the sun is not only used for industrial generation, currently the transportation industry also utilizes electrical energy sourced from the sun for propulsion and domestic needs. This study discusses the potential of electrical energy that can be generated by solar PV with a capacity of 2x550 Wp which will be implemented on cadet training ships. Solar irradiance is the most important component for the process of generating electrical energy, where later the irradiance value will become electrical energy using solar PV media. The irradiance value is obtained from a web application called solarglobalatlas which already has big data about the irradiation value in various places. This study took irradiation values in the coordinates area -2.953161°, 104.886022° (-02°57'11", 104°53'10") South Sumatra. The data was taken for 12 months to ensure that the data radiation experienced two seasons according to the characteristics of the area. The best irradiance values occur at 11.00 am – 01.00 pm. The results of the discussion show that the annual electrical energy that can be generated by solar PV with a capacity of 2x550 Wp using the monocrystalline PV type is 1,338.2 kWh with the largest electricity production peak occurring in August of 114.4 kWh. Meanwhile, the smallest production of electrical energy occurred in February at 87.2 kWh.

Keywords: Generation Industry, Irradiance, Solar PV, Transportation.

1 Introduction

The use of fossil energy to fuel ships at this time is one of the contributors to the increasing greenhouse gas effect[1]. The results of the International Convention for the Prevention of Pollution from Ships say that currently, ship operations must find new technologies and ways, especially for the fuel used to reduce gases that can increase the greenhouse effect[2]. One of the fuels that can reduce the effect of greenhouse gases is

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to use renewable energy. One of the renewable energies that is currently being rapidly developed in its use and development is energy that comes from the sun using photovoltaic (PV) media.

The potential for renewable energy sourced from the sun in Indonesia has a value of 207,898 MW (80 kWh/m2/day)[3]. The potential for new renewable energy for the generation of enormous electrical energy is not wasted by the Government of Indonesia, especially for the needs of public transportation modes. The Indonesian government has issued Presidential Regulation Number 55 of 2019 concerning the Acceleration of the Battery Electric Vehicle Program for Road Transportation[4].From these regulations, it can be developed more broadly not only for land transportation but can also be developed for the field of water transportation, especially in the field of crossings[1].

The use of electrical energy for crossing transportation using ferry boats can utilize renewable energy in the form of the sun with the help of solar PV as a medium for converting solar energy into electrical energy. In its application, it is necessary to take into account the need for solar PV to generate electrical energy and a battery to store the electrical energy generated by solar PV for the smooth operation of ferry boats.

In the design of ferry boats using solar PV to generate electricity, of course, it is necessary to pay attention to the technical and economic aspects of the design. The most important technical aspect that must be taken into account is related to the potential of electrical energy that can be generated from a PV system design. For this reason, through this research, the authors make calculations of the potential for electrical energy that can be generated by the PV system that will be installed on a solar-powered crossing boat that will utilize a training ship owned by Politeknik Transportasi Sungai, Danau dan Penyeberangan Palembang

2 Methods

The steps taken in this study can be seen in Figure 1. Figure 1 explains that the research methodology was carried out starting from problem identification, literature study, loading data collection, simulation using globalsolaratlas and finally the analysis process was carried out to produce systematic research.

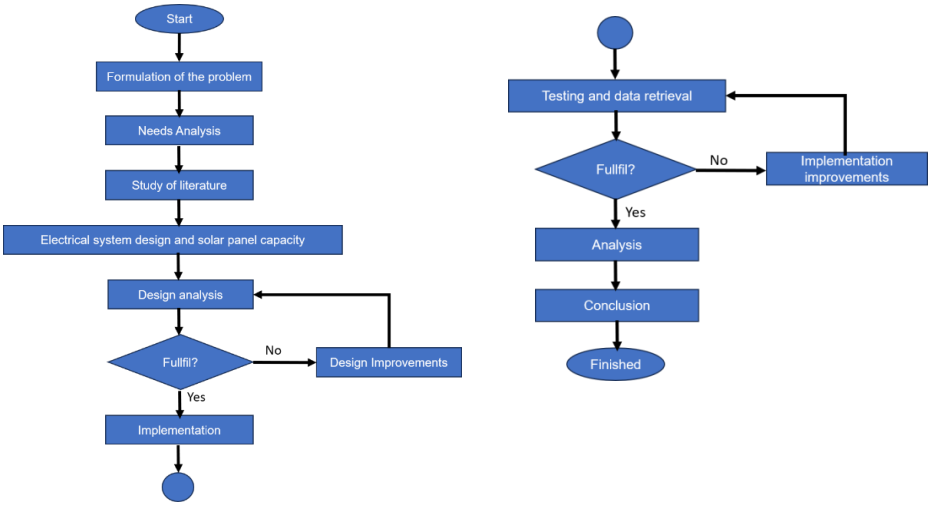

Figure 1. Research flowchart

3 Analysis and Design

a. Electrical System Design

Electrical system design is needed to ensure that the system can work well according to design and calculations. Apart from that, electrical design is needed to determine the specifications of each component so that they can function well and be connected to each other. Meanwhile, designing the solar panel mount is necessary to ensure that the size of the mount matches the size of the solar panels used in this research so that operations can run well.

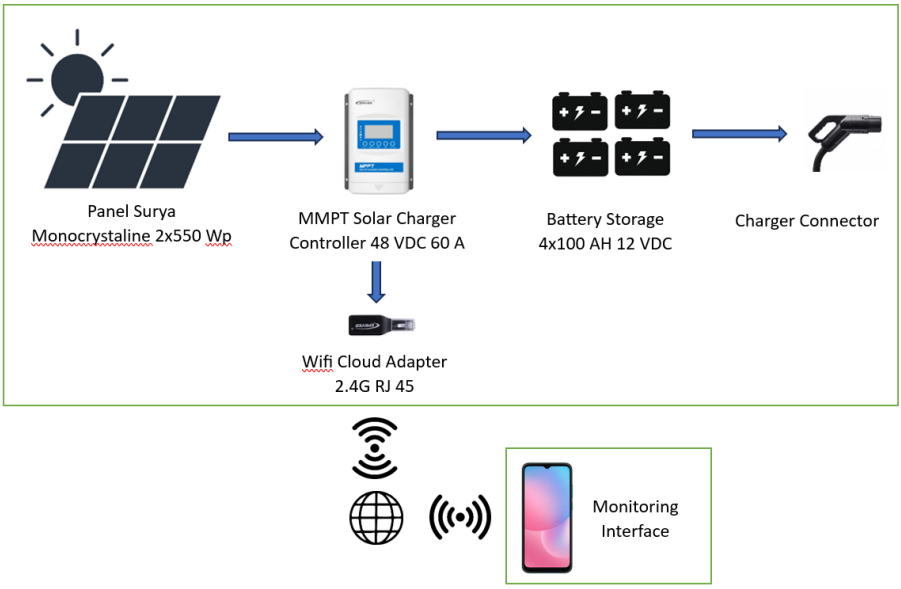

Figure 2. Block diagram of research

The system designed in this research is as shown in Figure 2. In the block diagram it can be explained that the solar panel that will be used is a monocrystalline type with a capacity of 550 Wp. The solar panel functions as a producer of electrical energy that converts solar irradiation, then the electricity produced goes into the MPPT charging controller with a capacity of 60A and a voltage of 48 VDC to manipulate the voltage and current so that the electricity output matches the battery specifications as a place to store the electricity produced. The electrical output from the MPPT charging controller has a voltage of 48 VDC because the batteries are arranged in series.

b. Solar Panel Output Simulation

Solar panels can produce electrical energy that comes from the sun by utilizing solar irradiation which will be converted into electrical energy. To determine the potential electrical energy that can be produced by solar panels, solar irradiation data is needed. This research takes solar irradiation data using a web application called globalsolaratlas. This irradiation data was taken in the area around the Politeknik Transportasi Sungai, Danau dan Penyeberangan Palembang.

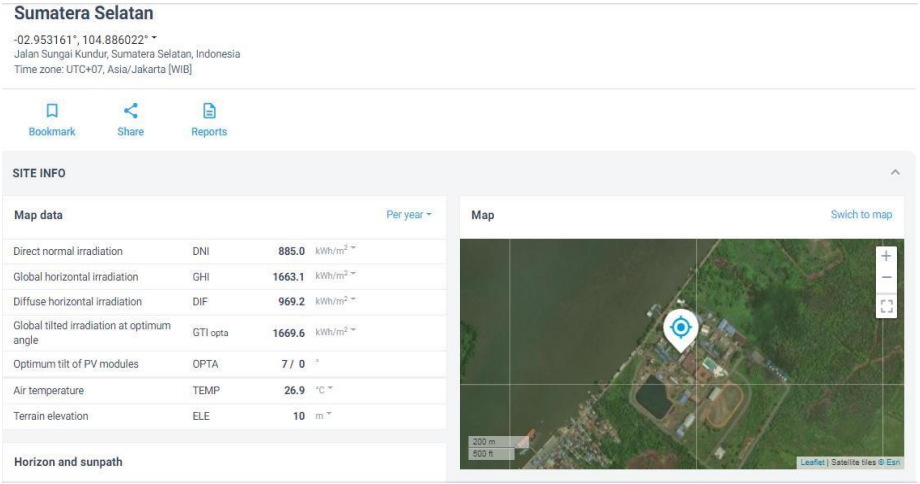

Figure 3. Geographical location of data collection

Hasil nilai irradiasi ini nantinya ajan menjadi data utama dalam perhitungan potensi energi listrik yang akan dihasilkan oleh PV dengan kapasitas 2x550 Wp. Data irradiasi yang ditunjukkan oleh tabel 5.1 merupakan data nilai irradiasi matahari selama satu tahun. Pengukuran nilai irradiasi tersebut menggunakan sensor pengukuran irradiance matahari yang dihubungkan dengan bigdata aplikasi website globalsolaratlas sehingga memungkinkan data irradiasi setiap daerah dapat diakses darimanapun. Data tabel 5.1 menunjukkan bahwa nilai irradiasi terbesar matahari pada setiap bulannya dalam waktu satu tahun terjadi antara pukul 11.00 – 13.00 siang, karena pada saat itu posisi matahari memiliki jarak paling dekat dengan bumi diantara waktu lainnya.

Table 1. Solar irradiation values

Time	Month (Wh/m²)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
00.00	0	0	0	0	0	0	0	0	0	0	0	0
01.00	0	0	0	0	0	0	0	0	0	0	0	0
02.00	0	0	0	0	0	0	0	0	0	0	0	0
03.00	0	0	0	0	0	0	0	0	0	0	0	0
04.00	0	0	0	0	0	0	0	0	0	0	0	0
05.00	0	0	0	0	0	0	0	0	0	0	1	0
06.00	18	12	17	39	39	36	29	18	24	31	43	24
07.00	80	81	98	156	195	189	172	150	142	124	115	87
08.00	133	159	228	240	291	291	278	251	260	228	182	134
09.00	183	207	266	329	352	344	332	312	282	270	264	199
10.00	237	269	326	408	417	404	380	395	345	332	322	254

11.00	266	292	355	421	436	408	403	412	358	335	333	280
12.00	252	283	334	380	404	388	376	370	319	300	299	267
13.00	216	236	287	328	322	328	311	314	268	238	236	216
14.00	179	195	229	255	248	261	260	271	229	175	180	167
15.00	128	139	226	182	169	183	200	201	202	111	109	111
16.00	82	86	106	99	93	115	138	138	101	49	60	70
17.00	30	39	34	23	21	28	41	31	15	6	8	17
18.00	0	1	0	0	0	0	0	0	0	0	0	0
19.00	0	0	0	0	0	0	0	0	0	0	0	0
20.00	0	0	0	0	0	0	0	0	0	0	0	0
21.00	0	0	0	0	0	0	0	0	0	0	0	0
22.00	0	0	0	0	0	0	0	0	0	0	0	0
23.00	0	0	0	0	0	0	0	0	0	0	0	0

The potential for solar PV electrical energy with a capacity of 2x550 Wp was obtained from simulations using irradiation data obtained from globalsolaratlas. Next, the data is processed using the same application to produce calculation results for the potential electrical energy produced.

This research takes daily electrical energy data in August. The output of electrical energy produced by solar PV can occur starting at 06.00, although the energy produced is still very small compared to the installed capacity. The PV output will start producing maximum electrical energy from 10.00 to 14.00 where the energy produced is almost close to the peak electrical energy that can be produced at peak times.

The peak time for electrical energy produced occurs at 11.00 at 604 Wp because at that time the sun is closer to the earth than at other times. Meanwhile, the electrical energy produced will experience a very drastic decline starting at 16.00 because the sun begins to set.

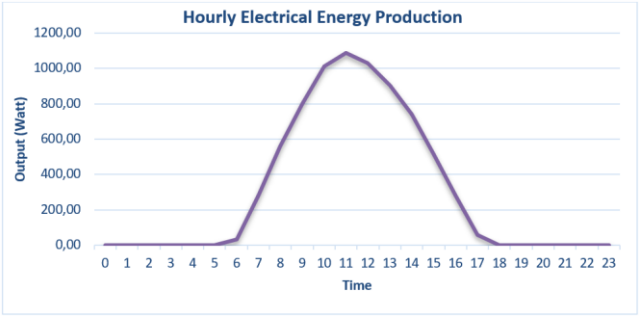

Figure 4. Hourly electrical energy production

The average potential electrical energy that can be produced in one day by a PV with a capacity of 2x550 Wp is 7306.2 Wp or 7,306 KWh. Meanwhile, the effective hours for solar PV to produce maximum electrical energy are only 3-4 hours. The annual electrical energy potential that can be produced by PV with a capacity of 2x550 Wp is 2190.06 kWh with the largest peak electricity production occurring in August at

205.92 kWh. Meanwhile, the smallest electrical energy production occurred in February at 156.96 kWh

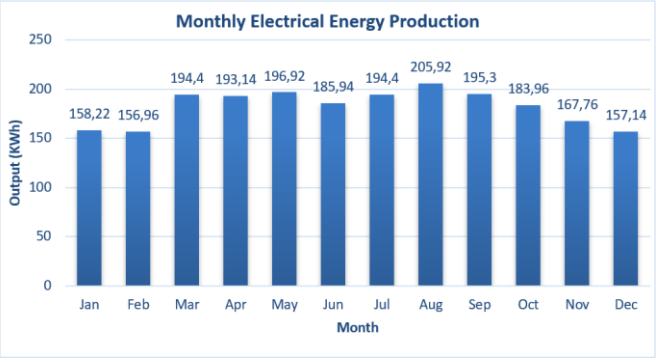

Figure 5. Monthly electrical energy production

The results of PV electricity production with a capacity of 2x550 Wp for one year are of course greatly influenced by the current season at the research location. This is in accordance with geographical conditions where the research location has two seasons in one year, namely the dry season and the rainy season. In the rainy season, of course, the sun's radiation on the earth will be more optimal so that the irradiance received by PV will be more optimal than in the rainy season.

4 Result and Discussion

The first step in implementing this research is to assemble and test each component before installing it on the solar panel roof frame. This is to ensure that all components can function as desired. Apart from that, testing activities on the work floor aim to minimize work if during testing of the system damage and non-functioning of each component is found.

Figure 6. Component testing

Apart from testing each component, testing of the solar panels is also carried out to ensure that the solar panels can produce electricity according to specifications

Figure 7. Solar panel testing

After testing the components and solar panels, the next step is to make a cover for the electric fuel filling station for crossing vessels. The next step is to install the solar panels on the roof frame and continue with the wiring and testing process.

Figure 1. Solar panel installation and testing

Figure 2. Installation of MPPT and electrical components

This research test was carried out to determine the output value of the solar panels installed on the roof frame of the electric fuel filling station. The indicator that is used as a reference is a monitor that displays the values of voltage and current.

Figure 3. Monitoring the electrical energy produced

Apart from using a monitor that displays the results of measurements of the electrical energy produced, measurements can also be viewed via an online application that can display measurement results in real time.

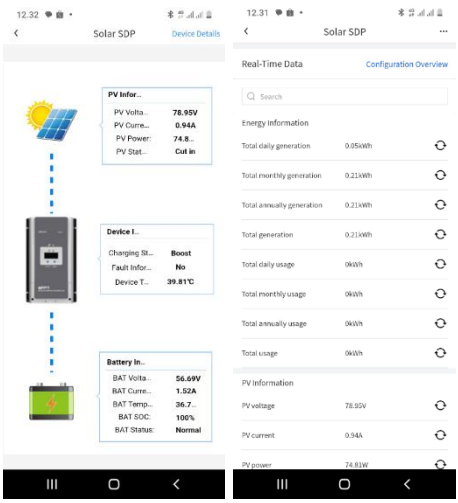

Figure 4. Online electrical energy monitoring

The measurement results of the electrical energy produced by the solar panels are then recorded as in table 5.2. Measurements were carried out for 1 day starting at 07.00 - 16.00, from the results of these measurements it was found that the measured temperature was in the range of 26.9 – 33.3 oC. Apart from that, the voltage produced is 67.2 – 94.4 Volts, while the current produced is 2.4 – 12 Amperes.

The greatest amount of electrical energy produced occurred at 11.00 with an electrical energy value of 1132.8 Watts, while the lowest production occurred at 07.00 with an electrical production value of 161.28 Watts. Apart from that, from the measurement results it can be said that the voltage value is always followed by the current value, where if one increases then the other also increases, except for different temperature values, because basically what is used is the irradiation value, not the temperature value of the environment.

Table 1. Electrical energy output measurement results

Time	Temperature (oC)	Voltage (V)	Current (A)	Power (W)
07.00	26,90	67,20	2,40	161,28
08.00	30,00	72,00	5,40	388,80
09.00	31,70	76,80	6,72	516,10
10.00	32,70	80,00	8,76	700,80
11.00	33,10	94,40	12,00	1132,80
12.00	33,30	91,20	11,40	1039,68

13.00	33,20	89,60	11,04	989,18
14.00	31,20	86,40	10,20	881,28
15.00	31,10	80,00	9,36	748,80
16.00	29,80	72,00	6,96	501,12

5 Conclusion

The conclusion of this research is that after data collection, calculations and data analysis, it can be concluded that:

1. The potential for electrical energy production from PV with a capacity of 2x550 Wp can produce annual electrical energy of 2,190.06 kWh kWh. The production of electrical energy that will be produced is very dependent on the solar irradiance that reaches the solar PV, so that one of the determining factors and optimization of electrical energy production by PV is the weather because it greatly influences the value of irradiance that will reach the solar PV.
2. The solar panel system can work well at electric fuel filling stations and can produce electrical energy for electrical fuel for the electricity needs of ferryboats.
3. The actual measurement results of the electrical energy produced by solar panels occurred at 11.00 with an electrical energy value of 1,132.8 Watts, while the lowest production occurred at 07.00 with an electrical production value of 161.28 Watts.

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