Analysis Of Potential And Performance Planning Of Solar Solar Power Plant In The Faculty Of Psychology University Of Diponegoro

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DOI: 10.29322/IJSRP.10.06.2020.p10233

http://dx.doi.org/10.29322/IJSRP.10.06.2020.p10233

Abstract-Indonesia is a country geographically located in equator which has a great potential in terms of solar energy utilization. This is because the magnitude of solar radiation is influenced by the location of latitude, atmospheric conditions, and the position of the sun against the equator. According to Power Data Acces Viewer NASA in 2019 Indonesia has a relatively high radiation rate of 5.5 kWh/m2/day. This is a big advantage for Indonesia in terms of the utilization of solar energy into electrical energy through Photovoltaics. Faculty of Psychology on Diponegoro University has a building that carries the concept of Undip First Bioclimatic and Biophilic Green Building. The building has a motorcycle parking facility and a rooftop that hasn't been well optimized. With a high level of solar radiation every day, the building located can take advantage of the rooftop and motorcycle parking facilities become a large PLTS siteplan. PLTS On Grid is a PLTS system integrated with the PLN grid, where PLN is the primary energy supplier and PLTS as an additional energy supplier. Through software PVSyst 6.43, the potential and performance of the planning of PLTS in the Faculty of Psychology Diponegoro University is expected to have a potential of 387.7 MWh annually. After going through the process of converting electrical energy reduced to 374.11 MWh which divided into 260.05 MWh used to supply the load and 114.06 MWh delivered to the network of PLN Grid.

Index Terms- *Photovoltaic, PLTS, On Grid, PVSyst 6.43*

I. INTRODUCTION

Increasing energy needs can be used as an indicator of a country's prosperity, but at the same time it will cause problems in its supply efforts. Most people still rely on fossil energy to meet their energy needs, so the longer the existing fossil energy will be depleting. The condition of the fossil energy reserves that continues to decrease is anticipated by the Government of Indonesia to further increase the use of New and Renewable Energy. At present the Government of the Republic of Indonesia through the RUPTL (Electricity Supply Business Plan) targets the New and Renewable Energy mix (EBT) to reach 23% by 2025. Meanwhile as of October 2019 the use of EBT has only reached 12.1%. The development of solar power for electricity is projected at 6.5 GW in 2025 and 45 GW in 2050 or 22% of the solar potential of 207.9 GW [1]. Indonesia is a country that is geographically crossed by the equator so that it has great potential in terms of utilization of solar energy. This is because the amount of solar radiation is influenced by the location of latitude, atmospheric conditions, and the position of the sun against the equator [2]. Indonesia, which is located at 6o LU - 11o LS and 95o - 141o BT has a relatively high average radiation level of 4.8 kWh / m2 / day [3]. Based on these facts, of course, Indonesia has a large capital to develop photovoltaic technology to generate electricity from solar energy. Some factors that influence the efficiency of solar cell output power are solar radiation, solar cell temperature, solar panel orientation, solar panel tilt angle, and shadow effect. [4]. to maximize the output power produced, solar cells must obtain maximum solar radiation and relatively low temperatures are needed so that the resulting output power increases. Diponegoro University has seven campuses spread across various regions in Central Java as a lecture facility. One of them is the main campus located on Jalan Prof. Soedarto, S.H. Tembalang UNDIP campus is the center of all Diponegoro University academic community activities consisting of 11 faculties and 1 vocational school with a total land area of 1,352,054 m2 [18]. Astronomically, the Faculty of Psychology, Diponegoro University is located at 7.07475 oLS and 110.4386 oBT. As a faculty that uses a new building as of January 2019, the building has a variety of lecture-supporting facilities including lecture and administration buildings, laboratories, libraries, sports facilities, motorized parking facilities, rooftops, small mosques, etc. This building was built with the initial concept of "Undip's First Bioclimatic and Biophilic Green Building" which is environmentally friendly and supports awareness about climate change. The motorcycle parking facilities of the Faculty of Psychology at Diponegoro University are in the form of an open parking lot with an area of 1,014 m2. Another potential area is the rooftop which is located at the very top of the building with an area of 963 m2.

Figure 1. *Rooftop* faculty of Psychology

The research aims to design and analyze the potential and performance of PLTS by utilizing and optimizing the use of land for motorcycle and rooftop parking facilities at the Faculty of Psychology, Diponegoro University as a daily supply of electricity connected to the grid of PLN (On Grid) as a source electrical energy using PVSyst 6.43 software.

II. Research Methods

2.1. Data Retrieval

At the stage of this research, data collection from NASA Prediction of Worldwide Energy Resources Higher Resolution Daily Time Series Climatology Resource for SSE-Renewable Energy is used to determine various meteorological and climatological parameters in the planning area in the City of Semarang during the 2019 period. As for some data required for the execution of this research are as follows:

Table 1. The intensity of solar radiation in the city of Semarang in 2019

Month	Solar Radiation ($kWh/m^2/hari$)
January	4,60
February	5,29
March	4,55
April	5,08
Mey	5,41
June	5,14
July	5,38
August	5,94
September	6,49
October	6,54
November	6,14
December	5,50
Average	5,50

Table 2. Temperature in the city of Semarang in 2019

Month	Temperature (^oC)
January	25,28
February	25,18
March	25,03
April	25,72
Mey	25,16
June	24,21
July	24,34
August	25,19
September	26,35
October	27,51
November	27,66
December	26,38
Average	25,66

The data in table 1 and table 2 are the two meteorological parameters needed in the simulation. In addition to these two data, there are existing irradiation data to determine the effect of irradiation duration on the PLTS electricity production. The irradiation old data was obtained from the Meteorology Climatology and Geophysics Agency, Semarang Climatology Station.

Table 3. Long exposure to the sun in the city of Semarang in 2019

Month	.Long exposure (Hour)
January	4,58
February	4,85
March	6,04
April	6,95
Mey	8,49
June	8,69
July	9,33
August	9,69
September	9,78
October	9,91
November	8,03
December	6,11
Average	7,70

In addition, data collection to support this research was also obtained through measurement of estimated daily load usage at the Faculty of Psychology, Diponegoro University. This data is needed as an estimate of the use of daily loads supplied by PLN electricity both on weekdays and holidays. Data is collected by manual observation periodically and the results are obtained according to hourly usage in a day as in table 4 below.

Table 4. Estimated hourly load data at the Faculty of Psychology building

Time (WIB)	Load (Watt)	
	Work Hour	weekend
00.00 – 00.59	6237	4943
01.00 – 01.59	6237	6173
02.00 – 02.59	6237	6173
03.00 – 03.59	6237	6173
04.00 – 04.59	6237	6173
05.00 – 05.59	6237	6173
06.00 – 06.59	19677	4859
07.00 – 07.59	43359	4859
08.00 – 08.59	118916	4983
09.00 – 09.59	141178	4983
10.00 – 10.59	145804,5	33307
11.00 – 11.59	186152	6507
12.00 – 12.59	125074	6552
13.00 – 13.59	134633	8224
14.00 – 14.59	185823,5	16197
15.00 – 15.59	136953,5	14514
16.00 – 16.59	127885	41314
17.00 – 17.59	116065	17108
18.00 – 18.59	101863	18748
19.00 – 19.59	67052	18508
20.00 – 20.59	44085	8700
21.00 – 21.59	11777	8700
22.00 – 22.59	6921	7070
23.00 – 23.59	6237	6158
Total	1756877,5	267099

From the data in table 4 we can see that the amount of electricity used during working days (5 days) is 1.757 MWh per day and during holidays (2 days) is 0.267 MWh.

2.2. Simulation

Utilization of solar energy in motorcycle and rooftop parking facilities at the Faculty of Psychology, Diponegoro University, Diponegoro University, located in Semarang City, Central Java, has become a PLTS that has considerable potential. With the potential use of solar energy and the use of large electrical energy consumption at the Faculty of Psychology, Diponegoro University, a system called PLTS OnGrid was chosen, where the source of electrical energy used to meet the

electrical energy needs of the Diponegoro University Psychology Faculty was not only supplied by PLTS, but by the grid of PLN. This is because the power supply provided by PLTS is still insufficient to estimate the use of daily loads at the Faculty of Psychology, Diponegoro University, so we need another power supply source that can meet the daily load needs. This PLTS is of the OnGrid system because during weekend conditions the use of daily loads is very low due to the lecture and teaching and learning process that is on vacation, while the power that can be supplied by the PLTS is fixed then the system will flow electricity into the grid or grid of PLN (Grid) to help meet electricity supply in Indonesia and reduce the use of power plants with fossil fuels and replace them with new and renewable energy. The design of PLTS in motorcycle and rooftop parking facilities at the Faculty of Psychology, Diponegoro University uses PVSyst 6.43 software as the main software to process the data obtained and identify analysis of potential and performance and potential energy generated in the designed solar system. PVSyst is a software package / software used for the learning process, measurement (sizing), and data analysis of the complete solar system. PVSyst was developed by Geneva University, which is divided into grid-connected systems, stand-alone systems, pumping systems, and direct current networks for public transportation (DC-grid). PVSyst also features a database of extensive and diverse meteorological data sources, as well as PLTS component data. Some examples of meteorological data sources that can be used on PVSyst are sourced from MeteoNorm V 6.1 (interpolation 1960-1990 or 1981-2000), NASA-SSE (1983-2005), PVGIS (for Europe and Africa), Satel-Light (for Europe), TMY2 / 3 and SolarAnywhere (for USA), EPW (for Canada), RetScreen, Helioclim, and SolarGIS (paid).

Figure 2. PVSyst 6.43

III. Result and Analysis

3.1 PVSyst 6.43 Result

Based on the results of the PVSyst 6.43 simulation without taking into account the influence of the shadow / shading factor, PLTS Faculty of Psychology, Diponegoro University has the optimal potential to produce electrical energy of 387.77 MWh per year. Where the PLTS system requires as many as 730 Kenika NPS320W solar panels and 2 Princeton Power Systems type GTIB-100-G1.2. The solar panel has a tilt angle of 9o and azimuth of 17o adjust the conditions in the field. The PVSyst 6.43 simulation results in the PLTS Faculty of Psychology at Diponegoro University can be seen in table 5 below:

Table 5. Electric Energy Potential Faculty of Psychology Based on PVSyst 6.43

	GlobHor kWh/m²	T Amb °C	GlobInc kWh/m²	GlobEff kWh/m²	EArray MWh	E Load MWh	E User MWh	E_Grid MWh
January	142.7	25.30	136.3	131.2	26.14	42.56	18.93	6.22
February	148.1	25.20	144.0	139.0	27.55	37.29	17.00	9.55
March	141.1	24.00	140.7	135.8	27.13	41.07	17.92	8.20
April	152.5	25.70	157.2	152.0	30.14	39.31	19.89	9.19
May	167.4	25.20	178.6	173.2	34.28	42.56	23.50	9.60
June	154.2	24.20	167.2	162.0	32.32	39.31	22.50	8.71
July	166.7	24.30	179.6	174.1	34.60	41.07	23.64	9.77
August	183.8	25.20	193.5	187.8	36.96	42.56	26.06	9.63
September	192.0	26.30	195.3	189.7	36.88	37.82	22.20	13.42
October	201.5	27.50	198.4	192.4	37.31	42.56	25.20	10.81
November	184.2	27.70	176.9	170.9	33.51	40.80	23.34	9.01
December	170.5	26.39	162.0	156.1	30.95	39.58	19.87	9.96
Year	2004.7	25.58	2029.7	1964.2	387.77	486.48	260.05	114.06

Based on table 5 the electrical energy generated by the PLTS Faculty of Psychology UNDIP is 387.77 MWh per year before being converted into AC electricity by an inverter. After going through the process of electrical energy conversion and current reversal, the resulting electrical energy is reduced to 374.11 MWh per year with the distribution of 260.05 MWh to supply the burden of the Faculty of Psychology UNDIP and the remaining 114.06 MWh is sent to the PLN grid system (Grid). The maximum production capacity of this PLTS is 234 kWp.

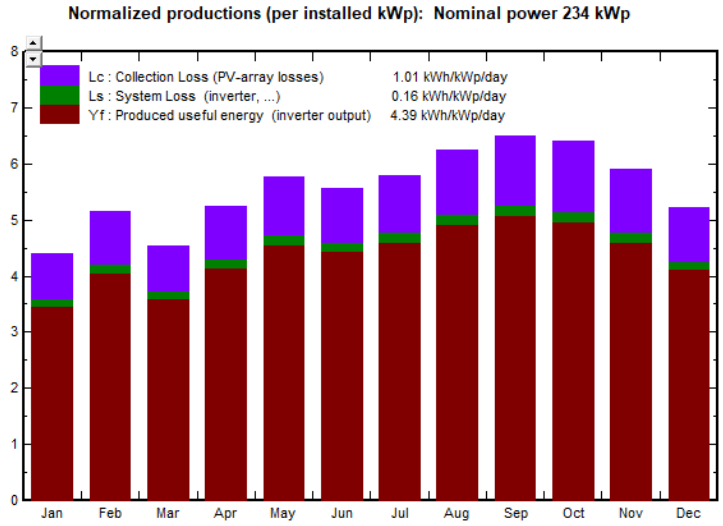

Figure 3. Graph of electricity production by PLTS in normal conditions

Based on the figure 3 electrical energy produced by the Solar Power Plant of the Faculty of Psychology, Diponegoro University, which has a diverse and fluctuating electric energy production results each month. With the largest electricity production in September and October during the dry season and the lowest in January during the rainy season.

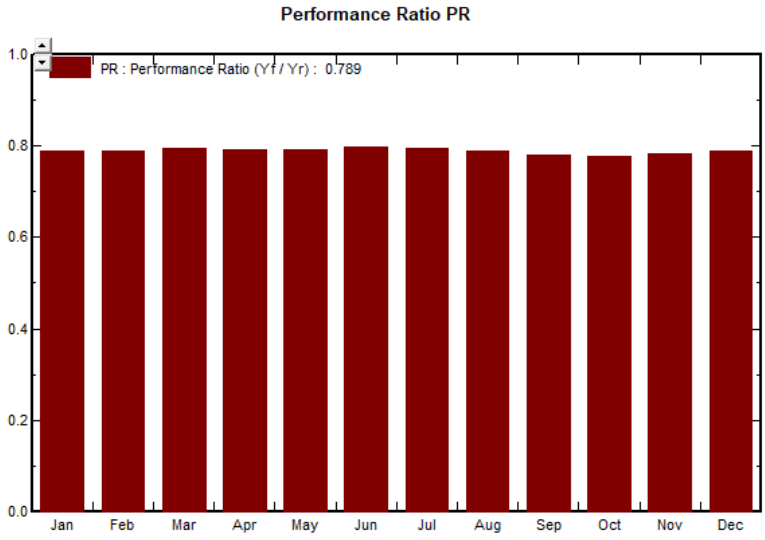

Figure 4. Performance Ratio Graph of PLTS Faculty of Psychology

Performance Ratio or the ratio of the performance of the Solar Power Generation System (PLTS) Faculty of Psychology, Diponegoro University is the ratio or level of comparison of electric energy produced effectively (used) with electrical energy that will be generated if the system continues to work in standard conditions (STC). Based on Figure 4 it can be seen that the Solar Power Generation System of the Faculty of Psychology, Diponegoro University has a fairly good level of performance ratio of 78.9%.

3.2 Analysis of PLTS Electrical Energy Production Faculty of Psychology

Based on the simulation results of the design of the Solar Power Generation Faculty of Psychology UNDIP with PVSyst 6.43 software obtained the results of the production of electrical energy each month. The amount of electrical energy produced by the Solar Power Generation Faculty of Psychology UNDIP is influenced by factors such as radiation intensity and temperature, according to the parameters contained in the Geographical Site Parameters in the PVSyst 6.43 database.

3.2.1 Radiation Intensity

The intensity of solar radiation is the amount of energy received by the earth per unit area per unit time whose value changes depending on several factors, such as the astronomical location (latitude) location, the daily and annual apparent motion of the sun, and the state of the Earth's atmosphere. The level of intensity of solar radiation or what is referred to as solar irradiation is an important and major parameter in determining the potential of solar power plant planning and the systems and supporting components used. This is because the working principle of solar panels that convert solar energy from radiation intensity into direct electrical energy (DC). The value of the electrical energy produced depends on the intensity of solar radiation received by solar cells. In table 6 the highest intensity of solar radiation in January and the largest electrical energy in October. This is because the month of October is the peak of the dry season where in general the sky has fewer clouds than the rainy season and the intensity of solar radiation emitted to the earth reaches more to the surface of the earth.

Table 6. Relationship between radiation intensity and PLTS energy production

Month	Intensity ($kWh/m^2/hari$)	Energy (MWh)
January	4,60	26,14
February	5,29	27,55
March	4,55	27,13
April	5,08	30,14
Mey	5,41	34,28
June	5,14	32,32
July	5,38	32,60
August	5,94	36,96
September	6,49	36,88
October	6,54	37,31
November	6,14	33,51
December	5,50	30,95
Average	5,50	32,14

Based on table 6 it can be seen that the largest electricity production was in October which reached 37.31 MWh and at that time the intensity of solar radiation was in the highest value too, which was 6.54 kWh / m2 / day. So it can be concluded that the greater the intensity of solar radiation received, the greater the electrical energy produced by solar panels.

3.2.2 Temperature

Regional temperature affects the maximum operability of solar energy. Ideally, solar panels operate at 25ºC. An increase in temperature of 1ºC (from 25ºC) results in the total power generated by the solar panels being reduced to 0.5%. The relationship between average temperature and the electrical energy produced is shown in table 7

Table 7. Relationship between temperature and PLTS energy production

Month	Temperature (ºC)	Energy (MWh)
January	25,28	26,14
February	25,18	27,55
March	25,03	27,13
April	25,72	30,14
Mey	25,16	34,28
June	24,21	32,32
July	24,34	32,60
August	25,19	36,96
September	26,35	36,88
October	27,51	37,31
November	27,66	33,51
December	26,38	30,95
Average	25,66	32,14

From table 7 above, it is obtained a comparison graph per month between temperature and electricity production. It can be seen that the largest electricity production in October reached 37.31 MWh when the temperature was relatively high, which was 27.51ºC. But from the results obtained, the value of electrical energy and temperature are fluctuating, this happens because the electrical energy produced is more dependent on the intensity of solar radiation which is the main parameter in the production of electrical energy by solar cells. The temperature value does not change much or it can be said that the range of change is small (2.6ºC).

3.2.3 Irradiation Time

Irradiation time affects the energy production of solar panels, because when the sun is insulated short means less solar radiation is received in one day, and vice versa. Electrical energy when there is a day where short insulation is different from the time of long insulation. Data related to the irradiation duration and the amount of electric energy production in PLTS Faculty of Psychology UNDIP can be seen in the table below.

Table 8. The relationship between solar energy irradiation and energy production

Month	Time (jam)	Energy (MWh)
January	4,58	26,14
February	4,85	27,55
March	6,04	27,13
April	6,95	30,14
Mey	8,49	34,28
June	8,69	32,32
July	9,33	32,60
August	9,69	36,96
September	9,78	36,88
October	9,91	37,31
November	8,03	33,51
December	6,11	30,95
Average	7,70	32,14

From the table above we get a comparison graph per month between temperature and electricity production as follows:

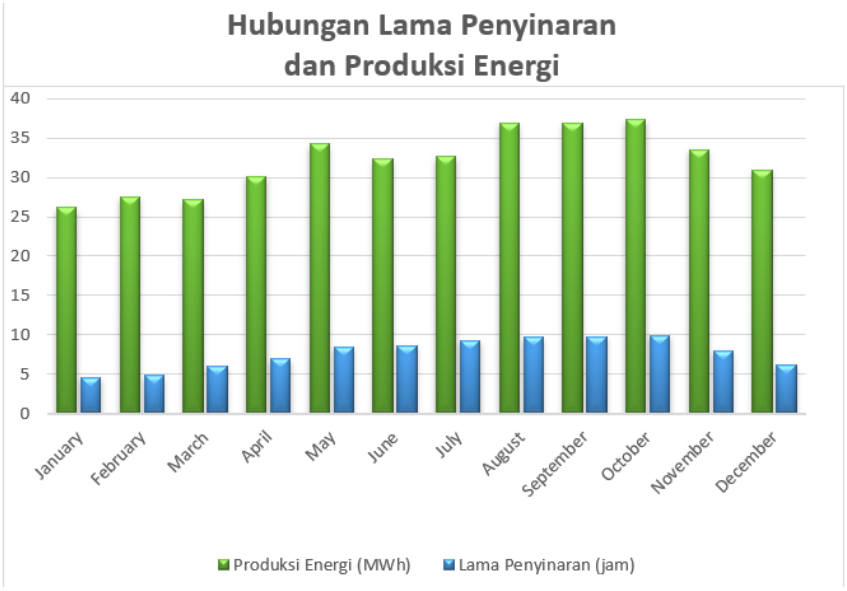

Figure 5. Graph of The relationship between solar energy irradiation and energy production

Based on table 8 and figure 5 it can be seen that the largest electricity production was in October which reached 37.31 MWh and at that time the irradiation / insulation time was also relatively high at 9.91 hours. This is certainly appropriate because the longer irradiation time generally occurs during the dry season, where long insulation makes the intensity of solar radiation on the day related also more, thus making solar panels capable of producing more maximum electrical energy.

IV. CONCLUSION

Based on research entitled the analysis of the potential and the performance of solar power plant planning (PLTS) in the Faculty of Psychology, Diponegoro University Building using PVSyst 6.43 software, it can be concluded that the PLTS system designed in the PLTS planning of the Faculty of Psychology, Diponegoro University is a system connected to the PLN network (OnGrid). In designing the system using 730 modules which are divided into 340 panels in the motorcycle parking area and 390 in the rooftop area. For the tilt angle of the solar panel is 9º with azimuth angle 17º with fixed tilt type support. The components used are 730 pieces of Kenika brand NPS320W solar panels with a capacity of 320 Wp, For the inverter is the Princeton Power System brand type GTB-100-G1.2 with a capacity of 100 kW of 2 pieces. The amount of electrical energy produced by PLTS is 387.77 MWh / year, after going through the process of energy conversion and current reversal to 374.11 MWh. With the distribution of 260.05 MWh the power is used for the purposes of using electricity itself at the Faculty of Psychology, Diponegoro University and 114.06 MWh electricity is distributed to the grid of PLN each year. The amount of performance ratio (performance ratio) per year based on PVSyst 6.43 simulation is 78.9% with a nominal nominal maximum power output power of 234 kWp and when the STC condition is 210 kW.

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