Designing a solar power plant model as an energy mix at Darma Persada University

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Abstract. Universitas Darma Persada (Unsada) energy profile has an average of almost 2300 kWh everyday. This energy profile is quite high especially at noon, and the existence of solar power plant potential as an electricity producers shows that it is appropriate if Unsada were pushed to utilize this electricity producers as a diffusion of energy supply. Therefore, a research is needed especially in power usage data, daily insulation data, solar power plant production specification data from power plant and regulations on the use of renewable energy, electricity to be supplied and power plant system. From the results of processing the data, will be obtained an output of Electricity System and Unsada Electric Energy profile. The solar power plant system that will be develop for the additional power supply is a hybrid solar power system with power plant electrical supply which power is generated at 50.4 kWp. 420 m\(^2\) of land is required for the installation of solar panels (can be installed on additional power roofs) and as many as 336 solar panels with 4 locations in each location of 84 solar panels.

1. Introduction

1.1. State of the review on application the feasibility of renewable energy

Case Study Feasibility Analysis of Renewable Energy Supply Options for Small to Medium-Sized Tourist Accommodations is done by G.J. Dalton, D.A. Lockington and T.E. Baldock [1]. This research utilizes the electricity load from three accommodations that have implemented a hybrid system for renewable energy. Special operational characteristics, such as 24-hour operations.

Techno-Economic Feasibility of Grid Connected Solar PV System in Bangladesh is done by Alam Hossain Mondal and Sadrul Islam [2]. This study analyzes the technical and economic feasibility of the 500 kW PV grid system at Rajshahi Bangladesh.

Design and Economic Analysis of a Stand-Alone PV System to Electrify a Remote Area Household in Egypt is done by Abd El-Shafy A. Nafeh [3]. The Remote Household in Egypt area was carried out by Abd El-Shafy A. Nafeh [3]. This study presents a complete design and life cycle cost analysis-alone Photovoltaic (PV) systems, which are carried out for one house stairs in the town of Rudies Abu, the
Egyptian Sinai Peninsula, which is located isolated and remote and far from the national electricity network.

Faisal Ahammed and Abdullahil Azeem conducted research about An Economic Analysis of Solar PV Micro-Utility in Rural Areas of Bangladesh [4]. This study analyzes the economic feasibility of Micro-Utility PV in Manikgang Bazaar of Bangladesh, using the Net Present Value (NPV), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Discounted Pay Back Period.

Universitas Darma Persada which move in educational services education has 14 hours of electricity operating characteristics (8.00 to 22.00). To be able to provide good service, Unsada needs a sufficient, continuous and reliable supply of electrical energy. In the event of a power outage from Power plant, Unsada uses a Diesel Power Plant as a source of electrical energy. Oil-fueled plants, in addition to expensive operational costs also cause air pollution and noise. The expensive cost of Diesel Power Plant was caused by it is high cost of fuel.

Unsada's electrical energy profile shows that during the daytime the use of other electricity is an average of 2300 kWh per day. This energy profile is associated with the magnitude of the daily intensity of sunlight as a producer of electrical energy, then it shows that it would be very feasible if Unsada was encouraged to utilize electrical energy sourced from renewable energy. Based on the background above, in this study a diffusion of Solar Power plants will be carried out as an energy supply at Unsada. For this reason, an analysis of the technical aspects will be carried out to determine whether or not the use of Solar Power Plant is feasible.

Solar cells are composed of two layers of semiconductors with different charges. The top layer of solar cells is negatively charged while the bottom layer is positively charged. Silicon is the most common semiconductor material used for solar cells.

2. Method

The method of data collection is done in the following ways: First observation method which is collecting data by conducting direct observations of Unsada locations. Then literature study, which is collecting data from reference books and journals that are relevant to the topic of research. Last interview, namely data collection by conducting direct questions and answers to employees in the PT. PLN East Jakarta Distribution.

2.1. Analyzing method

2.1.1. Data type. The data obtained in this study are grouped into two types, namely.

2.1.2. Primary data. Primary data is data obtained based on a survey directly to the research location. These data include: data on the use of electrical energy at the University of Darma Persada July to December 2016 data on the Unsada daily Insulation.

2.1.3. Secondary data. Regulatory data on the use of renewable energy is secondary data obtained through internet searching. Other secondary data is data obtained through literature and journals relating to the use of solar power as a power plant. Stages of Research on the Study of Utilization of Solar Power Generation (PLTS) as a power supply at Unsada, is carried out with stages of research:

- Collecting data, starting from the data on electricity consumption in Unsada which is recorded directly at the East Jakarta Distribution PLN, load data installed in Unsada, daily solar insulation data and maximum temperature data for East Jakarta, specification data and production of Solar Power Plants (PLTS) which has been developed by PLN in Jakarta, and regulatory data that regulates the use of renewable energy.
- Analyzing the profile of electrical energy in Unsada, to determine the characteristics of the use of electrical energy.
Calculating the electrical energy that will be supplied from PLTS which will be developed at Unsada is planned to supply electricity as much as 10% of the average electricity consumption, especially for lighting loads. Determine the PLTS system to be developed, taking into account the energy consumption profile and the potential of daily solar insolation. Calculate the power generated by PLTS. Calculating PLTS component capacity.

3. Results and discussion

Unsada's electrical energy needs are obtained from the National Electricity Company (PLN) with a power capacity of 950 kVA. Unsada has a generator with a capacity of 375 kVA, which is used as an electricity reserve in the event of a power outage from PLN. The operation between the PLN supply and generator is done automatically by using Change over Switch (COS).

The electrical system at Darma Persada University consists of one Main Distribution Panel (MDP) which is divided into six (6) Sub Distribution Panel (SDP), namely: SDP Rectorate Building, SDP Exacta Faculty Building, SDP Non Exacta Faculty Building, SDP Auditorium, SDP Baiturrahman Mosque, and SDP Taman. Electrical Energy Darma Persada University. The results of the measurement of electrical energy at Darma Persada University from Automatic Meter Reading PT. PLN East Jakarta Distribution in the period from May to December 2016, indicating that electricity consumption in Unsada is at 08.00 to 20.00 high compared to usage with other hours. The highest usage is at 12.00-13.00 which almost reaches 348 kWh.

3.1. Calculating electricity energy that will be supplied from PLTS

PLTS which will be developed at Unsada is planned to supply electricity as much as 10% of the average electricity consumption in the range from 08.00 to 16.00. From the table above, it is known that the average electricity consumption in Unsada in that time span is 2948.4 kWh per day.

The amount of electricity consumption (EL) that will be supplied by PLTS is 294.84 kWh in Unsada in the period of 08.00-16.00 which will be supplied by PLTS is 294.84 kWh.

3.2. Counting area array (PV Area)

The area of the array is calculated using the following formula: The amount of electricity consumption (EL) that will be supplied by PLTS is 294.84 kWh. For the daily solar insolation value (Gav), the lowest average insulating value will be used in 2016, which is equal to 6.5 kWh / m². The choice of this value is intended so that when the daily solar insolation is at the lowest value, the PLTS that will be developed still meet the large capacity generated. The efficiency of solar panels (ηPV) is determined at 12%, referring to the efficiency of 150W solar panels installed in general solar power plants.

For Temperature Correction Factor (TCF) a value of 0.94 is used. As is known that every increase in temperature of 1°C (from its standard temperature) on solar panels, then this will result in the power produced by solar panels will decrease by about 0.5% (Foster et al., 2010). The maximum temperature data for the Jakarta area is 37°C. These temperature data show that there is an increase in temperature of 12°C from the standard temperature (25°C) required by solar panels.

The amount of power decreases when the temperature around the solar panel increases 12°C from the standard temperature, calculated using formula and obtained by 9W. For the maximum output power of solar panels when the temperature rises 31°C calculated by the formula and obtained 141 W. The TCF value can be calculated by formula which is 0.94. Out efficiency (ηout) is determined based on the efficiency of the components that complement the PLTS.

A PLTS equipped with batteries, charge controllers and inverters, the large ηout is the result of multiplication between battery efficiency, charger controller, and inverter. Because PLTS will be developed by Unsada. This is only equipped with an inverter so the value for ηout is determined based on the efficiency of the inverter, which is equal to 0.9. If the values of EL, Gav, ηTCF and η are substituted in formula (4) then PV area is obtained: 420 m².
3.3. Calculating Power generated by PLTS (Watt peak)
From the calculation of the array area, the power generated by PLTS (Watt peak) can be calculated by formula. With an array area of 420 m², with the calculation of the array area, the power generated by PLTS (Watt peak) can be calculated by formula and obtained 50.4 kW peak. With an array area of 420 m², Peak Sun Insolation (PSI) is 1000W / m² and the efficiency of solar panels is 12%.

Table 1. Unsada daily energy.

| Time        | Energy (kWh) |
|-------------|--------------|
| 00:00-01:00 | 25.06666667  |
| 01:00-02:00 | 24.53333333  |
| 02:00-03:00 | 24.4         |
| 03:00-04:00 | 23.75        |
| 04:00-05:00 | 23.53333333  |
| 05:00-06:00 | 3.98         |
| 06:00-07:00 | 64.93333333  |
| 07:00-08:00 | 128.05       |
| 08:00-09:00 | 197.6        |
| 09:00-10:00 | 233.8833333  |
| 10:00-11:00 | 246.5333333  |
| 11:00-12:00 | 246.3333333  |
| 12:00-13:00 | 245.9333333  |
| 13:00-14:00 | 245.8363636  |
| 14:00-15:00 | 226.6909091  |
| 15:00-16:00 | 212.5        |
| 16:00-17:00 | 191.5333333  |
| 17:00-18:00 | 175.5333333  |
| 18:00-19:00 | 170.6        |
| 19:00-20:00 | 159.4666667  |
| 20:00-21:00 | 140.8        |
| 21:00-22:00 | 78.08333333  |
| 22:00-23:00 | 44.2666667   |
| 23:00-00:00 | 31.33333333  |

Table 1 shows the energy consumption in 2016. The table also shows the average energy consumption at the same hour. Energy use between 10:00 and 15:00 is higher than other times.

From the average daily energy, maximum use of energy (peak load) and time of use can be used as factors in determining the PLTS capacity to be supplied as the diffusion of electrical energy in Unsada. The National Energy Board is targeting an increase in the renewable energy mix from 5% in 2015 to 23% in 2025. PLTS projections reach 5000 MWp in 2019 and 6400 MWp in 2025. Unsada is expected to contribute with its own internal energy mix of 10% of its energy use.

3.4. Calculating the number of solar panels
The solar panel used as a reference has a PMPP specification of 150 W per panel. So based on these specifications, the number of solar panels needed for PLTS to be developed can be calculated using formula (6) and obtained 336 solar panels.
At present the electricity needs of the Union are supplied by PLN with a power capacity of 950 kVA. The power capacity shows that Unsada is a three-phase (3Ø) customer who must always keep the installation balanced in every phase. So that as an additional power supply for the use of electrical energy in Unsada, PLTS certainly must be balanced in supplying electrical power. Based on this, in this study, the PLTS to be developed will be divided into 4 single phase systems with 84 panels in each phase. So that the total number of panels needed for 4 single phase systems is 336 panels.

With 336 solar panels with 4 locations, each of them will consist of 84 solar panels. The panel circuit that forms an array for one phase is composed of 7 circuits (strings) that are connected in parallel with a series consisting of 12 panels connected in series.

The solar panels that are used as a reference are solar panels with VMPP specifications = 34.5V, IMPP = 4.35A and PMPP = 150W per panel (specifications of PLTS PLN solar panels). With these specifications, the size of VMPP, IMPP and PMPP on the array can be calculated as follows: VMPP array is 34.5V x 12 = 414 V, IMPP array is 4.35A x 7 = 30.45 A and PMPP array is 414V x 30.45 = 12,627 W (~ 13,000 W).

3.5. Counting inverter capacity
In the selection of inverters, work capacity is approached to the power capacity served. This is so that the inverter's work efficiency becomes maximum. PLTS to be developed in Unsada is divided into 4 single phase systems with PMPP is 13,000 W. Sunny Mini Central inverter (SMC) installed in PLN PLTS is generally used as a reference in selecting an inverter to this research. The SMC inverter is one type of inverter which is generally used for solar power plants that are hybrid with a grid.

3.6. Solar panel installation
To get maximum energy, the orientation of the installation of solar panels (arrays) towards the sun is an important thing to note. The greater the intensity of solar radiation, the higher the performance of solar panels. In general, to maximize the absorption of the sun in Indonesia, the panel must be directed with the following rules:

- If the location of the solar panel installation is below the equator, then the panel is directed leaning 50 - 150 to the north. These locations include Java, Madura, NTT, NTB, parts of Sumatra, Kalimantan, Sulawesi and Papua.
- If the location of the solar panel installation is above the equator, then the panel is directed leaning 50 - 150 to the south. This location includes parts of Sumatra, Kalimantan, Sulawesi and Maluku.
4. Conclusion

Based on the study of the technical aspects of Solar Power Plant diffusion at Unsada, it can be concluded that, Solar Power Plant system that will be developed for additional power supply is the hybrid system with Power Plant electricity supply of 50.4 kWp power generated. It needs 420 m² area for the installation of solar panels (roof can be used and its needs 336 solar with an arrangement of 4 locations with. Each location 84 solar panels.

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