Analysis Of Solar Power Plants With A Capacity Of 100 Wp With Automatic Transfer Switch In The Energy Conversion Laboratory Of Semarang State Polytechnic

Suwarti [1], Nur Fatowil Aulia* [2], Wahyono [3], Budhi Prasetyo[4], Dwiana Hendrawati[5], Baktiyar Mei Hermawan [6]
[1,2,3,4,,5,6]*Mechanical Engineering Department, Politeknik Negeri Semarang, Semarang, Indonesia*
Email address: * **nurfatowil.aulia@polines.ac.id**

Abstract— Solar energy is one of the renewable energy sources by utilizing the sun as its energy source. The planning of the PLTS uses an on-grid system, the system is still connected to the PLN network. The system is used as a backup for electricity flow. The system will work automatically when the PLN electricity flow is cut off by utilizing the Automatic Transfer Switch (ATS) control system. The PLTS was tested by measuring the voltage, current, and input and output power for 5 days from 09.00-15.00 WIB with data collection every 60 minutes. Then calculations were made to determine the efficiency of the PLTS. Calculations were also made of the energy produced by the panels needed and produced by the lights ideally and actually. The results of the DC voltage and DC current tests on average at a load of 70 Watts produced by the solar panel were 12.7 V and 2.41 A with a data collection period of 7 hours, producing energy of 214.3 Wh and producing the highest efficiency of 7.9% and the lowest 4.84%.

Keywords— PLTS, solar panels, ATS, Efficiency, Energy.

I. INTRODUCTION

Indonesia has a large and relatively stable solar energy potential throughout the year. Almost all regions of Indonesia have the potential for developing Solar Power Plants (PLTS) with an average power of 4 kWh/m2. Based on the region, the western region of Indonesia has a potential of around 4.5 kWh/m2/day with a monthly variation of 10%. While the eastern region of Indonesia has a potential of around 5.1 kWh/m2/day with a monthly variation of around 9%. The national solar energy potential reaches 4.8 kWh/m2/day or equivalent to 207,898 MW [2].

PLTS utilizes solar energy to become electrical energy through photovoltaic modules which are included in green energy and then become a new renewable, efficient, effective, reliable generator that is able to meet the needs of electrical energy. PLTS is one of the means to meet the community's needs for environmentally friendly electricity. Seeing that Indonesia is a tropical area, PLTS can be developed well. The use of solar energy will be more effective if in its application with an effective control system, the current control system is starting to shift to an automatic control system, so that human intervention in control is very small. When compared to manual work, the equipment system controlled by automation will provide advantages in terms of efficiency, safety, and accuracy. In planning this research using the Automatic Transfer Switch (ATS) tool for hybrid electricity PLTS to PLN. This hybrid system combines electrical energy from alternative energy sources using solar panels to PLN where these two sources of electrical energy will work alternately [1-3, 5-17].

II. METHODS

The research on "Designing and Construction of a 100 WP Capacity Solar Power Plant with Automatic Transfer Switch at the Energy Laboratory of Semarang State Polytechnic" will be carried out with the following time and activities:

A. Research Stages

To realize the research objectives, the stages carried out in the 8-month research period are:

a. Testing the characteristics of solar panels
b. Designing the ATS System
c. Testing and Analysis of System Work

B. Testing of PLTS Characteristics

In this study, the solar panels used were 50 Wp, 100 Wp, and 200 Wp. To support the operation of the system, parameters are needed in the form of voltage and current which will be measured using a voltmeter and ammeter. The test results are in the form of a graph of the characteristics of the power function against pressure. For this test, solar panel modules were used of 50Wp, 100 Wp, and 200 Wp. The power generated was measured using a voltage measuring instrument (Voltmeter) and a current measuring instrument (ammeter). The power generated is the product of voltage and current.

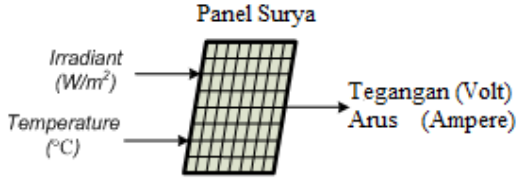

Fig.1. PLTS

C. Automatic Transfer Switch System Design

As an illustration of the ATS system mechanism, it is based on the system block diagram and the work system flow from the block diagram. The following is an illustration of the

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system flow and component scheme that can be seen in the block diagram in figure 4.1 and figure 4.2.

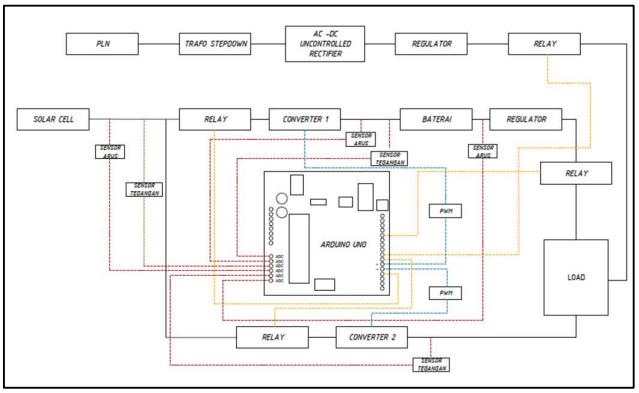

Fig.2. Arduino microcontroller component flow and schematic system

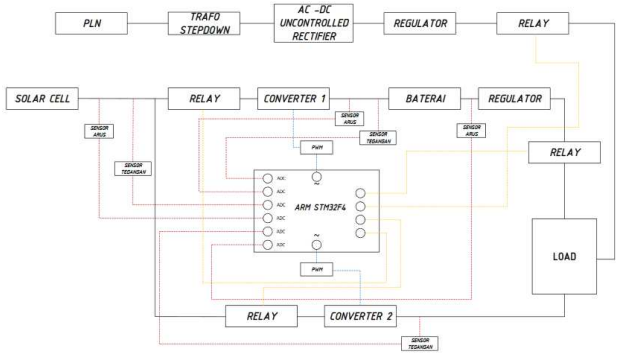

Fig.3. ARM microcontroller flow system and component schematics

The design of a hybrid supply system using PID-based auto selection switching functions as an automatic system for changing supply sources and regulating the duty cycle to maintain a stable power output value. To determine the performance of the hybrid supply system, two loads are used, namely a battery charging system with a capacity of 24 volts and 32 Ah and a sliding resistance load in the form of a resistor (R), adjusting the stable voltage setting of 24 and 20 Volts.

D. System Work Testing and Analysis

Before testing the supply system to the load, it is necessary to first install the control device to the solar panel. Testing this system through an automatic breaker, namely a relay controlled by a microcontroller in the form of ARM and Arduino. The parameters measured in this test are tests of the load on the solar panel which are read on the output voltage and current.

Indicators that show that the system built is in accordance with the expected objectives are if:

1. Solar panels can be used to charge the battery and supply the load directly if the battery is in a partial state.
2. The energy source from the battery can be used if the battery is full and the solar panel cannot generate power.
3. Solar panels are only used to supply battery charging if the battery is low.
4. The electricity source from the utility network/PLN is used when the solar panel cannot generate power and the battery is low.

III. RESULTS AND DISCUSSION

In this study, the value of solar radiation was measured using the clear sky calculator application. The size of the input power value produced can be influenced by the value of solar radiation obtained when the test was carried out. The test was carried out for 5 days. From the calculation results obtained, the largest output power value occurred at the minimum load, namely at a load of 20 W. This occurs because the input voltage value produced at the minimum load is greater when compared to the maximum load, namely at a load of 70 W, while the value of solar radiation is directly proportional to the amount of input power produced. This can happen because the value of the input power produced is obtained from the multiplication of solar radiation by the cross-sectional area of the solar panel.

The increase and decrease in the value of solar radiation produced can be influenced by several factors, namely temperature, humidity and cloud conditions that occur when the test takes place. Meanwhile, factors that can affect the absorption of solar radiation on solar panels such as the position of the solar panel to the sun, the angle of the solar panel, the type of solar panel, the cable used, the number of connections, and other PLTS components.

The problem factor that often occurs from photovoltaic is the relatively unstable value of the output power produced because it is influenced by the amount of solar radiation and the temperature of the surrounding environment. The size of the output produced by the solar panel depends on the amount of light absorbed by the solar panel. As a result of the movement of the sun, the light absorbed by the solar panel will change. The condition parameters that significantly affect the power produced by the PLTS are changes in the intensity of sunlight on the surface of the solar cell panel. The intensity of sunlight as an energy source in the application of solar cell panels, so that the power and efficiency of the output are highly dependent on changes in solar radiation. The parameter that is greatly influenced by solar radiation is the current (I) output of the solar cell panel while its effect on the voltage value (V) is quite small. The output voltage of the solar cell panel does not only depend on the intensity of sunlight received on the surface of the panel, but changes in heat distribution on the surface of the solar cell panel affect the power output of the solar cell panel.

A. Relationship between Efficiency and Time

Based on the data that has been taken for 6 days, the average DC voltage and DC current produced by the solar panel were 12.42 V and 2.68 A with a data collection time of

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7 hours, so the energy produced by the solar panel can be calculated as.

Energy panel = P x t
Energy panel = V x I x t
Energy panel = 12,42 x 2,68 x 7
Energy panel = 232,99 Wh = 0,23299 kWh

After knowing the energy released by the solar panel of 232.99 Wh can be compared with the household energy needs used, namely lamps. According to the specifications (ideal), the lamps used have a power of 150 watts and a total usage of 6 hours.

Ideal lamp energy = V x I x t
Ideal lamp energy = P x t
Ideal lamp energy = 150 x 6
Ideal lamp energy = 900 Wh = 0,9 kWh

Meanwhile, in actual fact, during the 6-day test, the average AC voltage and AC current produced were 202.24 V and 0.3 A with a data collection time of 7 hours with a lamp energy requirement of 6 hours.

Actual lamp energy = P x t
Actual lamp energy = V x I x t
Actual lamp energy = 202,24 x 0,3 x 6
Actual lamp energy = 364,032 Wh = 0,364032 kWh

After calculating and comparing the energy produced by the solar panels and the energy needed by the lamps ideally and actually. There is a difference in the amount of energy between the energy needed by the lamps according to the ideal calculation and the energy of the lamps according to the actual calculation.

Based on the ideal calculation, the energy produced by the Solar Power Plant with a Capacity of 100 Wp which is 0.23299 kWh cannot meet the energy needs of the lamps which is 0.9 kWh.

However, based on the actual, the energy produced by the Solar Power Plant with a Capacity of 100 Wp which is 0.23299 kWh cannot meet the energy needs of the lamps of 0.364032 kWh to meet it, additional capacity is needed from the PLTS.

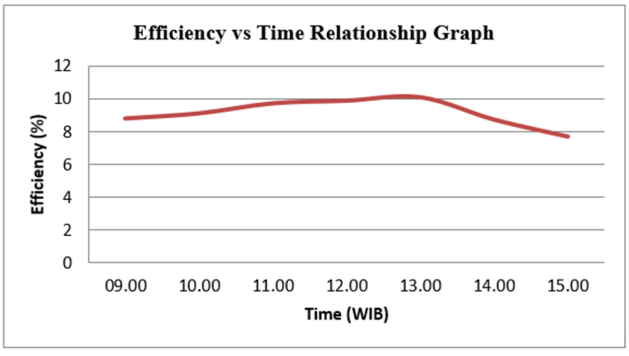
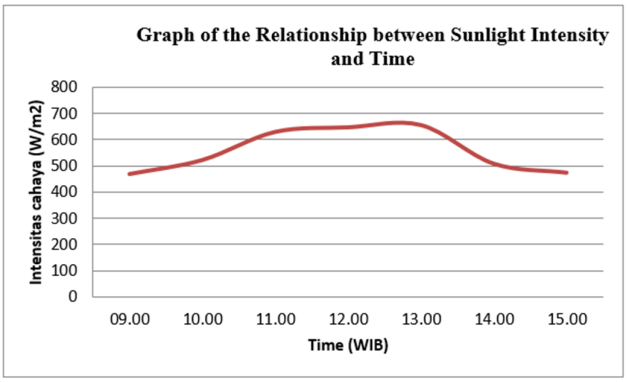


Fig.3. Efficiency vs Time Relationship Graph

Testing of solar panels in generating electricity that was tested produced a graph of the relationship between efficiency and time as shown in Figure 4.9. From the graph and table, the highest efficiency was 10.13% at 13.00 WIB and the lowest efficiency was 7.74% at 15.00 WIB. The efficiency of solar panels is influenced by several factors, one of which is the intensity of sunlight and the position of the sun in relation to the solar panels. At 15.00 WIB, there was a decrease in efficiency because the sunlight was covered by clouds. Meanwhile, when data collection for 6 days, the PLTS with a capacity of 100 Wp produced the highest efficiency of 11.30% and the lowest efficiency of 6.98%.

B. Relationship between Sunlight Intensity versus Time



The efficiency of solar panels is influenced by several factors, one of which is the intensity of sunlight and the position of the sun in relation to the solar panels. Graph 4.10 shows that on June 29, 2022, the highest solar intensity was 657.9 W/m2 and the lowest was 470.8 W/m2. This intensity was measured using the clear sky calculator application. Supposedly, the greater the light intensity value, the greater the voltage and current produced. This can happen if the panel conditions work optimally.

IV. CONCLUSION

Based on the results of data collection and analysis that have been carried out, the Design and Construction of a 100 Wp Solar Power Plant with Automatic Transfer Switch at the Energy Conversion Engineering Laboratory of the Semarang State Polytechnic obtained the following conclusions:

1. How to make a PLTS using the ATS system is by connecting the ATS from the PLTS and PLN sources with 2 sources that are assembled to produce 1 output circuit.
2. The performance results of the 100 Wp Solar Power Plant during the 5-day test produced an average solar panel input voltage and current at a load of 70 W of 12.7 V and 2.41 A and produced an average output voltage and current at a load of 70 W of 71.32 V and 0.3 A. So that it obtains the highest efficiency of 7.9% and the lowest efficiency of 4.84%.

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Based on the lamp capacity of 70 W used for 3 hours, it requires 210 Wh of energy. Thus, the energy produced by a 100 Wp capacity PLTS of 214.3 Wh can meet the needs of the lamp load..

REFERENCES

[1] Anonymous 1. 2012. Charging dan Discharging Baterai Aki pada Panel Surya http://www.panelsurya.com/index.php/id/batere/charge-and-discharge, diakses pada tanggal 14 Mei 2022.

[2] Artiningrum, T., Havianto, J., Lingkungan, S. T., Teknik, F., Mukti, U. W., Matahari, S., Listrik, P., & Surya, T. 2019. MENINGKATKAN PERAN ENERGI BERSIH LEWAT PEMANFAATAN SINAR MATAHARI IMPROVE THE ROLE OF CLEAN ENERGY THROUGH THE UTILIZATION Abstrak. 2(2), 100-115.

[3] Asy'ari, H. 2014. Aplikasi Photovoltaic Pada Rumah Tinggal Untuk Mengurangi Ketergantungan Energi Listrik Konvensional. Jurnal Emitor, 2.

[4] Ginting, H.P., & Sinuraya, W. E. 2014. Perancangan Automatic Transfer Switch (ATS) Parameter Transisi Berupa Tegangan dan Frekuensi Dengan Mikrokontroler Atmega 16. TRANSMISI, 16, (3),2014,129.

[5] Hasan, H. (2012). Perancangan Pembangkit Listrik Tenaga Surya Di Pulau Saugi. Jurnal Riset dan Teknologi Kelautan (JRTK) Volume 10,174.

[6] Jaelani O., Heri Suripto. 2020. Analisis Performa Dan Nilai Ekonomi Sistem Solar Cell Untuk Pengoperasian Pompa Air dengan Metode Eksperimental, Jurnal Rekayasa Mesin (Vol 15), 42-50.

[7] Mulyadi, Rahmad, 1995, Buku Panduan Pembangkit Listrik Tenaga Surya, Direktorat Teknologi Energi UPT-LSDE,BPPT.

[8] Prastiwi, A., Putri, R. I., Adhi Suwignjo, S., & Rifa, M. 2018. Photovoltaic Terapan: Photovoltaic Terapan (Vol 1). UPT Percetakan dan Penerbitan Polinema.

[9] Prih Sumardjati dkk, 2008, Teknik Pemanfaatan Tenaga Listrik, Departemen Pendidikan Nasional, Jakarta.

[10] Ramadhani Ing Bagus, "Instalasi Pembangkit Listrik Tenaga Surya, Dos and Don't"., Kementerian Energi dan Sumber Daya Mineral, 2018.

[11] Santoso Gatot, Slamet Hani, dkk. 2021. Pemanfaatan Pembangkit Listrik Tenaga Surya Sebagai Listrik Cadangan Budidaya Burung Puyuh Dilengkapi Dengan Automatic Transfer Switch (ATS) ,Jurnal Elektrikal (Vol 8). 45-52.

[12] Sudiharto, Indhana dkk, Rancang Bangun Sistem Automatic Main Failure (AMF) PLN-Genset Berbasis PLC Dilengkapi Dengan Monitoring, Surabaya, Jurnal Jurusan Teknik Elektro Industri PENS-ITS, 2011.

[13] Sufiyan Ifan dan Deni Hendarto, 2017, Rancang Bangun Perangkat Automatic Transfer Switch (ATS) Genset 1200 VA Sebagai Energi Listrik Cadangan,JuTekS (Vol 4).

[14] Sukma Widjaja, M., 2006. Eliminasi Harmonik Guna Perbaikan Bentuk Geolombang Keluaran Tegangan Inverter. JETri.6; 9-3

[15] Tjunawan, E. A., & Joewono, A. 2011. Sumber Energi Listrik Dengan Sistem Hybrid (Solar panel dan jaringan listrik PLN). Sumber Energi Listrik Dengan Sistem Hybrid (Solar Panel Dan …..,43)

[16] Utari, Evrita Lusiana. (2017). Perancangan Alat Induction Heating pada Pengolahan Teh Sangrai dengan Teknologi Energi Terbarukan (Solar Cell). Tekno 23(3),211-222.

[17] Zawahar, I., & Hotel The Royale. Krakatau Cilegon. Jurnal Energi dan Manufaktur Vol. 7, No.2, Oktober 2014;119-225,138.

https://jurnal.polines.ac.id/index.php/eksergi

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