Cirebon Annual Multidisciplinary International Conference (CAMIC 2024)

OPTIMIZATION POWER OF SOLAR PANEL POWER PLANT USING THE DUAL AXIS SOLAR TRACKER

1st Akhmad Maulana
Department Electrical Engineering, Faculty of Engineering
Universitas Swadaya Gunung Jati
Cirebon, Indonesia
akkhmd13@gmail.com

2nd Rindi Wulandari
Department Electrical Engineering, Faculty of Engineering
Universitas Swadaya Gunung Jati
Cirebon, Indonesia
rindi.wulandari@ugj.ac.id

3rd M. Riyad Ariwibowo
Department Electrical Engineering, Faculty of Engineering
Universitas Swadaya Gunung Jati
Cirebon, Indonesia
riyad_ariwibowo@ugj.ac.id

***Abstract*—Solar energy can be converted into electrical energy through technology such as solar panels. To optimize the use of energy from solar panels when exposed to sunlight, a system is needed that can follow the direction of the sun so that it can absorb as much light as possible. One solution is to use a dual axis solar tracker that uses an LDR sensor, Arduino Mega 2560, and servo motor. With this system, solar panels can move vertically and horizontally to increase energy production. Proven by the results of tests carried out at 09.00 WIB – 16.00 WIB, the total electrical energy produced by solar panels with a dual axis solar tracker system is 77.31 Watts/Day, which is higher than static solar panels which only produce 42 Watts of power. .04 Watt/Day, with an 83% increase in power compared to static solar panels. With this, the use of a dual axis solar tracker can significantly optimize solar energy efficiency.**

Keywords—***Optimization; Solar Tracker; Dual Axis***.

I. INTRODUCTION

Energy is a very basic need for human survival whose use and price tend to continue to increase. These factors cause the need to look for and use renewable energy sources that can be renewed in a short time and have a minimum environmental impact [1]. One of the renewable energies is solar energy, solar energy is an unlimited energy source, therefore solar energy can be utilized as an appropriate alternative energy source.

Solar energy is the form of renewable energy that comes directly from the sun through the form of solar radiation [2] [3]. Solar energy can be utilized by converting solar energy into electrical energy, one of which is by using photovoltaics (PV). The advantage of solar systems is that they can be deployed at small scale, allowing for their installation in many types of buildings, where they can be used for both thermal energy and electricity production [4]. The use of solar cells is effective for use in tropical regions such as Indonesia. Indonesia receives sunlight in almost the same period, namely around 12 hours throughout the year [5]. Optimizing the energy generated by solar panels during the time of sunlight then becomes a challenge in maximizing the existing energy potential.

Every day the sun moves from east to west and rises and sets. The current problem is that most of the installed solar panels are still static or stationary so they do not follow the movement of the sun. As a result, the capture of sunlight is not optimal and the resulting electrical power cannot be maximized. Therefore, it is necessary to create a solar panel system that always follows the direction of the sun and is able to absorb maximum sunlight.

A solar tracking system is a solar cell device which moves to face the sun continuously to improve the collection of irradiances [6]. Solar tracking is used in large grid-connected photovoltaic plants to maximize solar radiation collection and to reduce the cost of delivered electricity [7]. There are two main types of solar tracking systems, depending on the degrees of movement [8].

The aim of this study is to compare between the performance of Dual Axis Solar Tracker (DAST) and Static Solar System (SSS) or a solar system with fixed axis to assess the solar power potential [9]. Tracking strategy might significantly contribute to the development of photovoltaic plants with two-axis trackers. At least, 2% more energy than plants using some existing tracking strategies, even those defined as ideal [10].

The dual axis solar tracking system is built with a servo motor as a drive, the solar panels can be positioned vertically and horizontally to track the maximum orientation of sunlight throughout the day to increase the energy output produced by the solar panels [11].

II. METHOD

This research adopts a quantitative experimental method, the approach applied is system design and data analysis [12] [13]. The result is data using a dual axis sun tracking system which will be compared with data produced by static solar panels [14] [15]. The measurement system does not use a load, the variables measured are current, voltage and output power from the solar panel system. Table 1 shows the specifications of the solar panels being made.

Solar Panel Specifications 20 Watt

Peak Power (P_maximum)	20 W
Voltage (VMP)	18 V
Current (Imp)	1.14 A
Open circuit voltage (Vo)	1.29 A
Size	36 x 2 x 45 cm

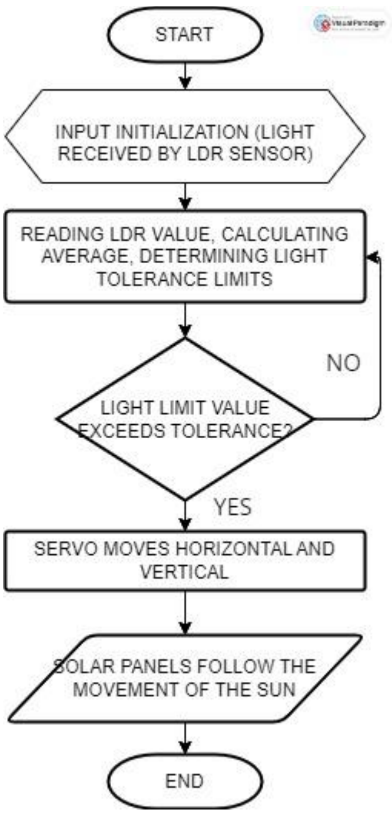

Figure 1. flowchart system of the dual axis solar tracker

Figure 1 shows the flowchart of the dual axis solar tracker system. LDR (Light-Dependent Resistor) is used to detect light intensity at four different angles: top-right, top-left, bottom-right, and bottom-left. Each LDR sensor will take its analog value at a certain angle, by taking the values from two adjacent LDRs on both sides (for example top and bottom, left and right) and calculating the average. After getting the average LDR value for each side, then calculate the difference between the light intensities on adjacent sides. This difference will be used to adjust the servo position to follow the light source. If the difference in light intensity exceeds the specified tolerance limit, the code will change the servo position to follow the change in light.

The stages of creating a dual axis solar tracker frame design were made using the software: SketchUp 2021. The results of the 3D design of this tool can be seen in Figure 2.

Figure 2. Top View Dual Axis Solar Tracker Design

The hardware design for this two-axis solar tracking system utilizes the Arduino Mega 2560 microcontroller as the controller. Solar panels as energy producers. To detect light intensity, an LDR sensor is used which will activate the servo in response. The solar panel movement mechanism is implemented via a 180 degree servo motor. As energy storage, a 12 V battery is used which holds the power generated by the solar panels, and the Step Down DC to DC MP1584EN Mini module is used to reduce the voltage before entering the Arduino.

The dual axis solar tracker will track or adjust the position of the solar panel so that it always faces the light source (the sun). This dual axis solar tracker is also equipped with an LDR sensor to detect light intensity. The working system of the dual axis solar tracker is that the solar panels automatically follow the movement of the sun in two axes, namely horizontal and vertical, depicted in figure 3.

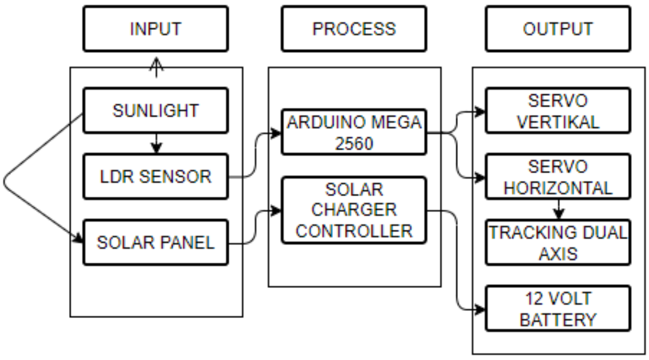

Figure 3. working system of the dual axis solar tracker

III. RESULTS AND DISCUSSION

A solar panel with a power of 20 Wp was installed on a dual axis tracker system model for experimental tests to calculate the power output show on the figure 4. For comparison, 20 Wp solar panel is installed statically (still) facing northeast with the solar panel angle set at a slope of 30º at (-6°73'16.6"S, 108°54'52.9"E). Testing was carried out in the field area of Kodim 0614 Sunyaragi, Cirebon.

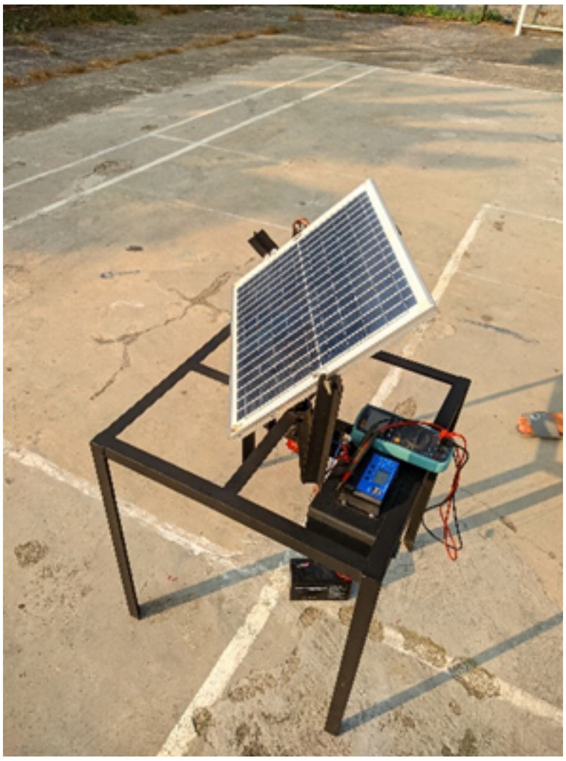

Figure 4. Solar tracker with two dual axys system

The test is carried out by calculating the current, voltage and output power values of the solar panel without using a load.

Ten measurements were carried out in one hour, where testing of the solar panels using a dual axis tracking system was carried out from 09.00 WIB to 16.00 WIB. Figure 5 shows the test results between the current produced by a solar panel with a dual axis tracking system and a static solar panel. The maximum current produced by the dual axis solar tracker is 0.89 A at 15:00, while the maximum current produced by the static solar panel is 0.56 A at 12:00. From this figure it can be concluded that the use of a dual axis solar tracker produces a more effective current.

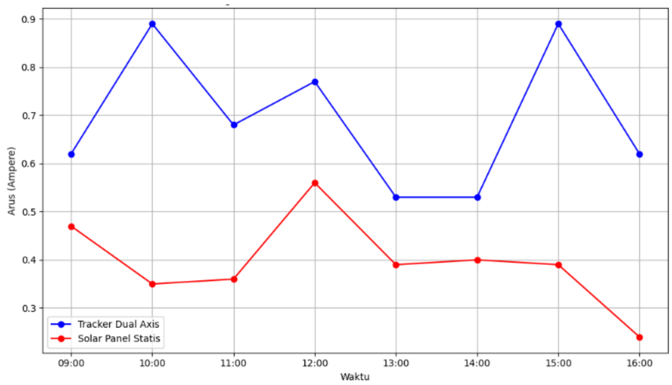

Figure 5. Comparison of electric current values between dual axis solar panels and static solar panels

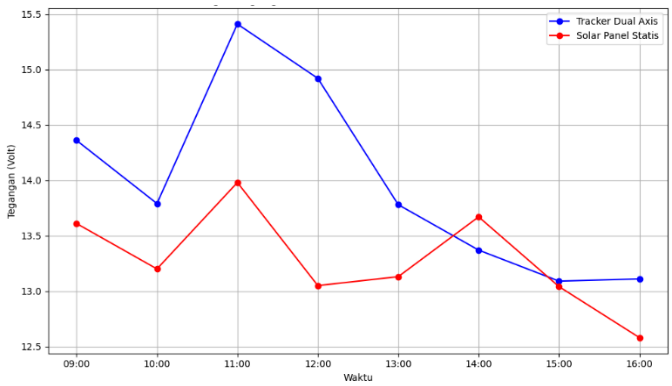

Figure 6. Comparison of voltage values between dual axis solar panels and static solar panels

In Figure 6, the maximum voltage produced by the dual axis solar tracker is 15.41 Volts (occurs at 11:00), while the maximum voltage produced by the static solar panel is 13.98 Volts (occurs at 11:00).

Power Calculation Analysis

From the power data recorded in Table 2, it can be seen the change in sunlight intensity from 09.00 WIB to 16.00 WIB, where the highest intensity of sunlight was achieved at 13.00 WIB where the light intensity reached 11,093 Lux. Meanwhile, the lowest light intensity was at 09.00 at 2597 lux.

A comparison between the power produced by solar panels with a dual axis tracking system and solar panels in stationary conditions can be seen at 10:00 with a light intensity of 4631 lux, the dual axis solar tracker produces a maximum power of 12.27 Watts. Meanwhile, the maximum power produced by static solar panels is at 12:00 WIB with a light intensity of 5196 lux, producing 7.31 Watts of power.

Solar Panel Specifications 20 Watt

Time	Solar Tracker Dual Axis (Watt)	Statis solar panel (Watt)	Difference (Watt)
09:00	8.90	6.40	2.51
10:00	12.27	4.62	7.65
11:00	10.48	5.03	5.45
12:00	11.49	7.31	4.18
13:00	7.30	5.12	2.18
14:00	7.09	5.47	1.62
15:00	11.65	5.09	6.56
16:00	8.13	3.02	5.11

From the data in Table 2, the comparison between dual axis solar tracker power and static solar panel power can be visualized in the graph in Figure 7.

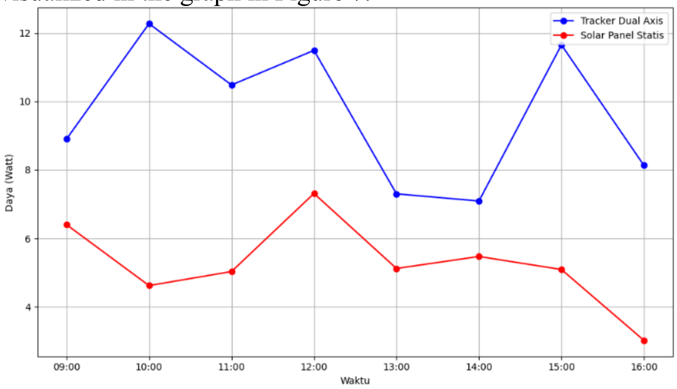

Figure 7. Comparison of power values between dual axis solar panels and static solar panels

From the results above, a very significant increase in power of 83% was obtained by the dual axis solar tracker compared to static solar panels, which is the result of various optimization factors. Compared to previous research conducted by Erwan Eko Prasetiyo in 2022 which resulted in a performance increase of 73.84% , the dual axis solar tracking efficiency produced in this research was higher with a difference of 9.16% [16]. Dual axis solar tracker is one solution to maximize power [17]. The dual axis solar tracker is able to dynamically follow the movement of the sun, avoid shadows that reduce panel performance, and ensure optimal absorption angles throughout the day. With these advantages, solar panels can maximize the potential of solar energy which can be converted into electricity effectively and efficiently.

IV. CONCLUSIONS

A dual axis solar tracker system with an LDR sensor, controlled by an Arduino Mega 2560 and two servo motors on the x and y axes, was successfully applied to a 20 WP solar panel. The use of dual axis solar trackers in PLTS has the potential to significantly increase the power produced compared to static solar panels. By optimizing current, voltage and power, and reaching maximum power earlier, this system can increase solar energy efficiency and productivity. Based on the results of testing solar panels with a dual axis solar tracker, the energy difference achieved was 83% per day with testing carried out for 8 hours. This shows that the use of dual axis solar tracking is more efficient and can help maximize the absorption of sunlight on solar panels compared to ordinary (static) solar panels.

REFERENCES

[1] P. Siagian, "Pengembangan Panel Surya 120 Wp Dengan Solar Tracker Double Axis Sebagai Bahan Pembelajaran Mahasiswa di Program Studi Teknik Mesin UHN," sprocket journal of mechanical engineering, vol. 3, no. 2, pp. 115-128, 2022.

[2] N. AL-Rousan, N. A. M. Isa and M. K. M. Desa, "Efficient single and dual axis solar tracking system controllers based on adaptive neural fuzzy inference system," *Journal of King Saud University – Engineering Sciences,* pp. 1-11, 2020.

[3] H. A, H. T and W. L, "Using solar energy to generate power hrough asolar wall.," *Journal of King Saud University – Engineering Sciences,* 2020.

[4] A. Barbon, C.-. Cueli, L. Bayon and P. F. Ayuso, "Influence of solar tracking error on the performance of a small-scale linier Frensel reflector," *Renewable Energy,* pp. 43-54, 2020.

[5] S. Manan, "Energi Matahari, Sumber Energi Alternatif yang Effisien, Handal dan Ramah Lingkungan di Indonesia," *Gema Tekologi,* 2009.

[6] B. Khadidja, K. Dris, A. Boubeker and S. Noureddine, "Optimisation of a Solar Tracker System for Photovoltaic Power Plants in Saharian region, Eample for Ouargla," *Energy Procedia,* vol. 50, pp. 610-618, 2014.

[7] W. Manosroi and P. k. Pitchaporn Prompattra, "Performance improvement of two-axis solar tracking system by using flat-mirror reflectors," *Energy Report,* vol. 6, pp. 9-16, 2020.

[8] E. T. Tchao, S. A. Asakipaam, Y. A. K. Fiagbe, B. Yeboah-Akowuah, E. Ramde, A. S. Agbemenu and B. Kommey, "An Implementation of an optimized dual-axis solar tracking algorithm for concentrating solar power plants deployment," *Scientific African,* vol. 16, pp. 1-12, 2022.

[9] A. Masih and I. Odinaev, "Performance Comparison of Dual Axis Solar Tracker with Static Solar System in Ural Region of Rusia," in *Ural Symposium on Biomedical Engineering, Radioelectronics and Information Technology (USBEREIT)*, Russia, 2019.

[10] L. Fernández-Ahumada, J. Ramírez-Faz, R. López-Luque, M. Varo-Martínez, I. Moreno-García and F. C. d. l. Torre, "Influence of the design variables of photovoltaic plants with two-axis solar tracking on the optimization of the tracking and backtracking trajectory," *Solar Energy,* vol. 208, pp. 89-100, 2020.

[11] H. Budiyanto, A. B. Setiawan and A. Siswati, "Pengembangan Pembangkit Listrik Tenaga Surya pada Greenhouse Hidroponik di

Desa Sutojayan, Kabupaten Malang," *Jurnal Pengabdian Dharma Wacana,* vol. 2, no. 3, pp. 160-69, 2021.

[12] R. Wulandari, Nurdiyanto, Taryo and N. Nugraha, "Rancang Bangun Sistem Irigasi Otomatis Berbasis RTC Menggunakan Solar Panel," *IJEIS (Indonesian Journal of Electronics and Instrumentation Systems),* vol. 12, no. 2, pp. 213-222, 2022.

[13] R. Wulandari, "DESIGN PROTOTYPE OF SMART DETECTOR ENVIRONMENT SYSTEM ON SEMICONDUCTOR DETECTOR STORAGE (HPGE)," *Journal of Green Science and Technology,* vol. 6, no. 2, pp. 65-72, 2022.

[14] S. O. a, H. P. b and R. C. c. a, "Two-Axis Solar Tracker Analysis and Control for Maximum Power Generation," *Procedia Computer Science,* vol. 6, pp. 457-462, 2011.

[15] J. F. Lee and N. A. Rahim, "Performance comparison of dual-axis solar tracker vs static solar system in Malaysia," in *2013 IEEE Conference on Clean Energy and Technology (CEAT)*, Lengkawi, 2013.

[16] E. E. Prasetiyo, G. Marausna and R. R. D. Rahmiullah, "ANALISIS PERBANDINGAN HASIL DAYA LISTRIK PANEL SURYA DENGAN SOLAR TRACKER DAN TANPA SOLAR TRACKER," *JTT (Jurnal Teknologi Terpadu),* vol. 10, no. 2, pp. 77-83, 2022.

[17] V. Mohanapriya, V. Manimegalai, V. Praveenkumar and P. Sakthivel, "Implementation of Dual Axis Solar Tracking System," in *First International Conference on Circuits, Signals, Systems and Securities (ICCSSS 2020)*, Tamil Nadu, 2020.