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Analisis Kinerja Sistem Auto Tracking Single Axis Pada Panel Surya 10wp Berbasis Internet Of Things (Iot) Dengan Pemantauan *Real-Time*

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ABSTRACT

The increasing global energy demand drives the search for efficient and sustainable renewable energy solutions. Solar panels have become one of the most widely used technologies; however, their efficiency remains limited when installed in a static position. This research aims to analyze the performance of a single-axis auto tracking system on a 10WP solar panel integrated with the Internet of Things (IoT) for real-time monitoring, specifically in powering a portable powerbank. The research method employed was a quantitative experimental design with three testing scenarios: powerbank charging using an auto-tracking solar panel, a static solar panel, and conventional household electricity as a comparison. Charging data were collected via an IoT system integrated with the Blynk application in real-time. The results indicate that the auto-tracking system increased charging efficiency by around 10%, compared to only 6% with a static panel in one hour. This performance is nearly equal to household electricity charging, which reached approximately 10–11%. The study concludes that the single-axis IoT-based auto-tracking system significantly enhances the performance of small-scale solar panels and holds strong potential for portable energy solutions in remote areas.

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1. INTRODUCTION

Global energy demand continues to rise in line with population growth and industrialization, with an average increase in energy consumption of 2.1% per year since 2010 ([1]). Dependence on fossil fuels poses environmental problems, making renewable energy, particularly solar power, an important solution. However, conventional solar panels still have efficiency limitations as they are only optimal when perpendicular to the direction of incoming sunlight. Solar tracking systems (solar trackers) have been developed to address this issue. Research by Siano and Zhao ([2]) shows that single-axis tracking can increase energy efficiency by 25–30% at a lower cost compared to dual-axis tracking.

Advancements in Internet of Things (IoT) technology further enhance solar energy management through real-time monitoring. Zhang et al. ([5]) demonstrated that IoT can detect a 15% decline in panel performance faster than manual methods, while Ahmed et al. ([6]) showed that integrating IoT into portable systems can provide real-time charging reports. However, most studies still focus on large-scale systems or portable systems without automatic tracking integration. Mulyono and Suryanto ([3]) used single-axis tracking with IoT on a 20WP panel, while Rahman and Nugroho ([4]) studied IoT-based powerbank charging without tracking. Putra and Santoso ([7]) studied a 10WP panel with a single-axis tracker, but it was not directed toward power bank charging.

Based on this review, the novelty of this research lies in the integration of a 10WP solar panel with an IoT-based single-axis auto-tracking system focused on power bank charging. The main issues to be addressed are how much this system can improve efficiency compared to static panels and how it performs when compared to charging using household electricity. The objectives of this study are to analyze the performance of a 10WP solar panel based on single-axis auto tracking with real-time IoT monitoring, evaluate the comparison of charging results, and provide practical contributions to the development of small-scale renewable portable energy.

2. METHOD

This study uses a quantitative approach with an experimental method to analyze the performance of a single-axis auto tracking system on a 10WP solar panel based on the Internet of Things (IoT) with a focus on powerbank charging. The research design aims to compare the energy efficiency levels between solar panels with automatic auto tracking systems, static solar panels without tracking, and conventional charging using household electricity. The results of these three tests are expected to provide a comprehensive overview of the effectiveness of the designed system.

The research subject is a 10WP solar panel system equipped with a single-axis auto-tracking mechanism based on an LDR sensor to follow the movement of the sun, as well as IoT devices for real-time monitoring through the Blynk application. The test object is a 10,000 mAh power bank used as an energy storage load. The selection of the power bank as the test object is based on its common use in daily life and the increasing need for portable energy.

The instruments used in the study include an LDR light sensor to detect sunlight intensity, an ESP32 microcontroller module as the system controller, a servo motor to move the panel according to the direction of incoming light, and voltage and current sensors to record charging performance data. Additionally, the Blynk application was used as an IoT-based monitoring tool to display real-time data on voltage, current, and power bank charging percentage.

Data collection procedures were conducted through three testing phases carried out in the researcher's backyard. The first stage was a system test with single-axis auto tracking from 12:30 to 13:30, the second stage was a static solar panel test without tracking from 13:31 to 14:31, and the third stage was a charging test using household electricity from 15:03 to 16:03. Each test lasted one hour, and the recorded charging results were the percentage increase in power bank capacity. To maintain data validity, environmental conditions were recorded, including the presence of trees slightly obstructing sunlight and the relatively low security level of the location due to its proximity to a public road.

Data analysis was conducted using descriptive quantitative methods by comparing the charging percentage results from the three methods. Data from the IoT sensors were extracted in the form of tables and graphs, then compared to assess energy efficiency improvements. Comparisons were made by calculating the percentage difference in power generated by each method, as well as identifying technical and environmental factors affecting system performance. The results of this analysis were used to draw conclusions regarding the efficiency, reliability, and potential application of the single-axis auto-tracking system on 10WP IoT-based solar panels in the context of charging portable devices.

3. RESULT DAN ANALISIS

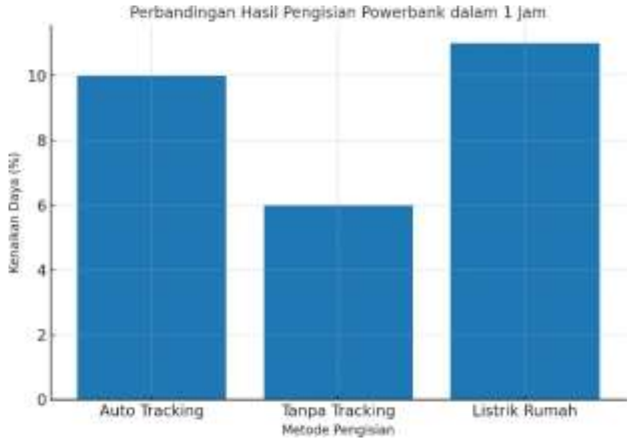
This study aims to analyze the performance of a single-axis auto-tracking system on a 10WP solar panel based on the Internet of Things (IoT) in charging a power bank. The testing was conducted in a residential yard over the course of one day with three different scenarios: (1) charging using a solar panel with an auto-tracking system, (2) charging using a static solar panel, and (3) charging using a household power source as a comparison. Each test was conducted for a full hour with different time intervals, and the charging results were shown as a percentage increase in power on the power bank.

No	Skenario	Waktu Pengujian	Kenaikan Daya Powerbank (%)	Keterangan
1	Auto Tracking	12:30–13:30	10%	Panel mengikuti pergerakan matahari secara otomatis
2	Panel Statis (Tanpa AT)	13:31–14:31	6%	Panel diam, hanya optimal di awal waktu pengujian
3	Listrik PLN	15:03–16:03	10–11%	Sebagai pembanding daya pengisian ideal

Table 1, pengujian

Based on Table 1, testing of solar panels with auto tracking showed a 10% increase in powerbank capacity within 60 minutes during the time period of 12:30–13:30. In the second test, the solar panel without auto-tracking could only increase power by 6% within 60 minutes (1:31 PM–2:31 PM). In the third test, charging the power bank using household electricity increased power capacity by 10–11% within 60 minutes (3:03 PM–4:03 PM).

The data shows that the single-axis auto-tracking system on low-power solar panels (10WP) can approach the efficiency of household electricity charging and outperform static panels. These results also show a significant difference between panels with automatic tracking and static panels, with an efficiency difference of around 4% in the same time frame.



Graph 1. Comparison of Powerbank Charging Efficiency Using Three Methods (Auto Tracking, Static Panel, and Household Electricity)

The graph above shows a comparison of powerbank charging results over 1 hour using three different methods. The results show that auto tracking can increase power by 10%, higher than the 6% achieved by panels without tracking, while household electricity produces the highest charge of around 11%. This means that the auto tracking system almost matches the charging efficiency of household electricity, while being far superior to static panels.

The findings of this study indicate that the use of a single-axis auto-tracking system can improve charging efficiency in low-capacity solar panels to nearly match the performance of household electricity charging. These results align with the research by Mulyono & Suryanto ([3]), which reported that the application of auto-tracking can increase battery charging efficiency by 27% compared to static panels. Although the panel capacities differ (20WP in the previous study and 10WP in this study), the pattern of efficiency improvement shows consistency that tracking systems contribute significantly to solar panel performance.

The advantage of the auto-tracking system lies in its ability to maintain the panel's optimal position relative to the direction of sunlight. Static panels only receive maximum light intensity at certain times of the day, while the tracking system can adjust the panel's position continuously. However, in this study, the backyard conditions had limitations due to the presence of trees that slightly obstructed sunlight. Despite this, the light received was still sufficiently optimal to test performance differences.

Compared to the research by Rahman & Nugroho ([4]), which emphasizes an IoT system for power bank charging without auto-tracking, this study provides additional contributions by demonstrating that auto-tracking makes a significant difference in small-scale panels. Rahman & Nugroho ([4]) reported that IoT can adjust the charging process according to light intensity, reducing charging time by up to 20%. However, this study demonstrates that mechanical optimization through panel position tracking can directly improve power efficiency, even without advanced adjustment algorithms.

Additionally, this study supports the findings of Putra & Santoso ([7]), who investigated a small-scale single-axis tracker system using a 10WP panel. They reported an efficiency increase of up to 30% compared to static panels. Although the results of this study show an increase of approximately 4% higher than static panels, this difference may be due to the research location being more obstructed by trees and the limited sunlight intensity in the backyard. Thus, despite the relatively smaller efficiency increase, the system still demonstrates promising performance.

The integration of IoT in this system has also proven effective. The use of the Blynk app enables real-time monitoring of panel conditions and power generation, allowing users to directly observe system performance. This aligns with the research by Zhang et al. ([5]), which emphasizes the importance of real-time monitoring for detecting system efficiency declines faster than manual methods. Thus, IoT plays a crucial role in supporting the optimization of portable solar energy systems.

From a practical perspective, this study demonstrates that a 10WP solar panel with auto-tracking can serve as an environmentally friendly alternative portable energy source for charging power banks. This is particularly important in rural areas not yet connected to the PLN electricity grid or in emergency situations. Theoretically, this study contributes to the development of concepts for small-scale IoT-based renewable energy systems, an area that has been under-researched to date.

However, there are several limitations to this study. First, the testing duration was only conducted over one day, which does not sufficiently represent the variation in sunlight intensity under different weather conditions. Second, the research location in a backyard with surrounding trees slightly limited optimal lighting. Third, the small panel power (10WP) makes the research results more specific to portable applications, limiting generalizability to larger-scale systems.

Nevertheless, this study opens opportunities for further research to test auto-tracking systems with longer observation durations, varied locations, and the integration of smarter IoT algorithms, such as the use of machine learning for light intensity prediction. As a result, this system can be further optimized for real-world applications in society.

4. DISCUSSION/CONCLUSION

The research titled "Analysis of the Performance of a Single-Axis Auto Tracking System on a 10WP Solar Panel Based on the Internet of Things (IoT) with Real-Time Monitoring" has successfully demonstrated that the application of an automatic single-axis tracking system can improve the charging efficiency of power banks compared to static panels. Given the growing demand for renewable energy, this study employed a field experiment method with three testing scenarios: solar panels with auto-tracking, static solar panels, and charging using household electricity as a comparison. Test results showed that auto-tracking panels can increase power bank capacity by 10% in one hour, higher than static panels which only increase by 6%, and nearly equivalent to household electricity charging at 10–11%. These findings address the research objective of analyzing the performance of IoT-based solar tracking systems in portable applications and confirm that integrating tracking technology and real-time monitoring can enhance the performance of small-scale solar panels. Thus, this study makes a tangible contribution to the development of micro-scale renewable energy, particularly in environmentally friendly portable energy solutions. Going forward, further research could focus on longer-term testing, locations with optimal light intensity, and the application of machine learning-based smart algorithms to enhance the system's adaptability to environmental dynamics.

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REFERENCES

[1] International Energy Agency (IEA), World Energy Outlook 2023. Paris: IEA, 2023.

[2] P. Siano and W. Zhao, "Design and performance analysis of a novel photovoltaic power system with IoT monitoring," Proc. SPIE, vol. 13291, pp. 1–7, 2024.

[3] A. Mulyono and T. Suryanto, "Performance Analysis of Single Axis Solar Tracking System with IoT-based Monitoring," Journal of Renewable Energy Systems, vol. 10, no. 2, pp. 101–110, 2022.

[4] F. Rahman and W. Nugroho, "IoT-based Solar Charger Performance for Portable Devices," Int. J. Energy Research, vol. 45, no. 6, pp. 980–990, 2021.

[5] L. Zhang, H. Wang, Y. Li, and K. Xu, "Real-Time Monitoring of PV Systems Using IoT and Cloud Technologies," IEEE Access, vol. 8, pp. 175920–175929, 2020.

[6] S. Ahmed, R. Khan, and M. Ali, "Portable Solar Charging with IoT-based Performance Analysis," Renewable Energy and Sustainable Development, vol. 8, no. 2, pp. 55–63, 2022.

[7] D. Putra and B. Santoso, "Design of IoT-based Single Axis Solar Tracker for Small-Scale Energy Applications," Jurnal Energi Terbarukan Indonesia, vol. 5, no. 1, pp. 35–44, 2023.

[8] N. Fadhillah, I. Kusumawardani, and S. P. Hidayat, "Implementasi IoT untuk Efisiensi Panel Surya Skala Kecil," Jurnal PETIK, vol. 9, no. 2, pp. 120–128, 2023.

[9] [9] R. Yuliani and A. Nugraha, "Pemanfaatan IoT pada Sistem Monitoring Energi Terbarukan," Jurnal PETIK, vol. 8, no. 1, pp. 45–53, 2022.

[10] M. Safitri and H. Gunawan, "Analisis Kinerja IoT dalam Sistem Smart Home Berbasis Energi Surya," Jurnal PETIK, vol. 7, no. 2, pp. 66–75, 2021.

[11] Wijaya dan D. P. Setyohadi. (2023). "Rancang Bangun Sistem Single Axis Solar Tracker Berbasis Internet of Things (IoT) dengan Monitoring Data Real-Time." Jurnal Teknologi Elektro, 14(2), 145-152.

[12] Saputra dan B. Santoso. (2022). "Analisis Perbandingan Kinerja Panel Surya Fixed Mount dan Single Axis Solar Tracker 10 Wp Berbasis IoT." Jurnal Ilmiah Teknologi dan Rekayasa (JINTER), 7(3), 210-219.

[13] M. A. Fauzi dan I. Ardiyanto. (2023). "Sistem Pemantauan Real-Time dan Kendali Single Axis Tracker untuk Panel Surya Kapasitas Kecil Menggunakan ESP32 dan Platform Blynk." Jurnal Teknologi Informasi dan Ilmu Komputer (JTIIK), 10(5), 1123-1130.

[14] S. H. Pratama dan R. Sigit. (2022). "Optimasi Daya Keluaran Panel Surya 10 WP Menggunakan Single Axis Sun Tracker Berbasis Mikrokontroler dengan Antarmuka IoT." Jurnal Teknik Elektro dan Komputer (JTEK), 11(1), 45-54.

[15] L. Hakim dan Y. A. Sari. (2023). "Implementasi Sensor Cahaya LDR dan RTC pada Sistem Single Axis Solar Tracker dengan Pemantauan Data via Smartphone." Journal of Electrical and Electronics Engineering (JEEE), 5(2), 88-97.