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Design and Build an Internet of thing (IoT) Solar Panel Monitoring and Solar Tracking System

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Abstract

Nowadays, solar panels as a solar power plant which is a renewable energy source require a tool to monitor the solar panel system. Solar panels can be controlled automatically by a tracking system using microcontroller instrumentation technology. A monitoring and solar tracking system has been designed and built using Arduino Uno R3 microcontroller, Node MCU ESP 8266, Humidity Sensor DHT-11 and PZEM-004T V3.0 based on Internet of Thing (IoT) displayed on smartphone communication devices using Blynk software. Tool testing was carried out in South Denpasar. The research methodology consists of a literature study, development of the first system to system refinement and system testing at one point of the building without any hindrance. The results of this study are that the Solar Tracking System shows that the LDR sensor readings are very responsive in receiving sunlight which functions to drive servo motors and the tool can monitor Solar Panels and read the characteristic value of the relationship between light intensity, temperature, load on the measurement results will be displayed on Blynk application menu that has been designed and generated power. The power output generated from the tracker is greater than without a solar tracker. The biggest difference in power between a solar tracker and without a solar tracker is 6.23 watts using a 20W load of LED lights. The performance increase obtained was 10.67%.

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1 Introduction

The tropical climate conditions and the high intensity of the sun's rays make it appropriate for Indonesia to install new renewable energy (EBT) such as solar power plants. On the other hand, the use of alternative energy also needs to be controlled and monitored so that the use of alternative energy can be precisely according to needs (Ratnasari et al., 2022). So that it can result in the need for new and renewable energy sources being something that is needed (Natsir et al., 2019). This is also supported by Indonesia's geographical location which is on the equator trajectory making the application of Photovoltaic (PV) technology very strategic if managed efficiently. One example is the utilization of solar thermal energy which is used as a source of electrical energy (Kurniawan, 2020). Its application in everyday life is to turn on street lights, garden lights, turn on traffic lights, and so on. Therefore, a tool is needed that can show the real-time use of electric power, making it easier for users to monitor electricity consumption (Pangestu et al., 2019). Apart from that, what needs to be considered is the weakness of using solar panels as renewable energy, always using a fixed (traditional) system. Where objects attached to solar panels are fixed or fixed (Asri & Serwin, 2019). For this, a design with an Arduino-based light-tracking sensor can be used.

The Industrial Revolution that is now changing the world and is widely used is the Internet of Things, a concept that aims to expand the benefits of Internet connectivity that is connected continuously (Jokanan et al., 2022). The Internet of Things can make it easier for us to control and monitor alternative and non-alternative electrical energy systems that exist with the help of the Internet and can be from remote places in real-time (Kurniawan, 2020). The result is digital in the form of numbers and graphics.

This study discusses the design and build of telemetry equipment parameters of IoT-based solar power plants. This study makes design and tests telemetry devices by measuring the values of the parameters of PLTS components with an off-grid system. However, this research only monitors solar panel data without increasing the power generated by solar panels with a solar tracking system (Fauzy et al., 2022).

This study discusses the design of an off-grid system solar power generation module, this study makes design and manufacture of a small-scale off-grid solar power plant system practice module with a power capacity of 320Wp. However, the monitoring data can only be accessed manually and cannot be connected to a smartphone via WIFI (Syahwil & Kadir, 2021).

Another study discusses monitoring electrical power in internet-based solar panels of Things (IoT) which aims to monitor the use of electric power in Internet-based solar panels using the Telegram application as an interface and ESP32 as a microcontroller and Pzem-004t as sensors. However, this research only monitors solar panel data without increasing the power generated by solar panels with a solar tracking system (Ratnasari et al., 2022).

Compare to the previous study, the authors designed a solar panel power monitoring system tool and a solar tracking system that will be made based on IoT used to monitor the degree of tilt, sunlight intensity, measure current, and a voltage obtained from irradiation on solar panels so that solar panel power data monitoring activities can use smartphone online with WIFI (Lindenmayer & Likens, 2009).

2 Materials and Methods

The research methods consist of a literature study, research framework (flowchart design), wiring diagram, designing an IoT-based monitoring solar panel system and solar tracking system, creating software and hardware design, also the development of the first system-to-system refinement and system testing at one point of the building without any hindrance.

Research Framework

The research framework identifies what is significant and provides research questions and objectives to help coordinate and focus our research effort. It will be for implementing the steps taken throughout the research. It is normally used as a guide for researchers so that they are more focused on the scope of their studies process (Amiri et al., 2014). Figure 1 shows the process of this study.

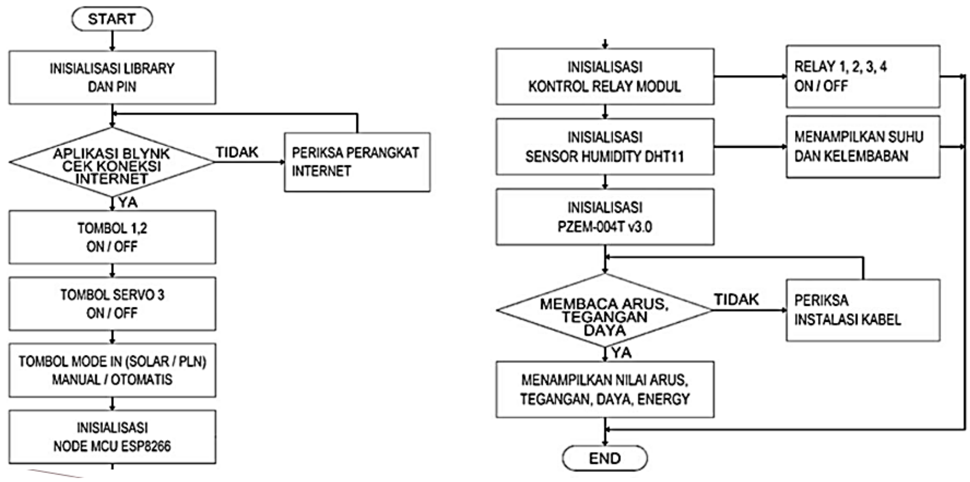

Figure 1. Flowchart monitoring system

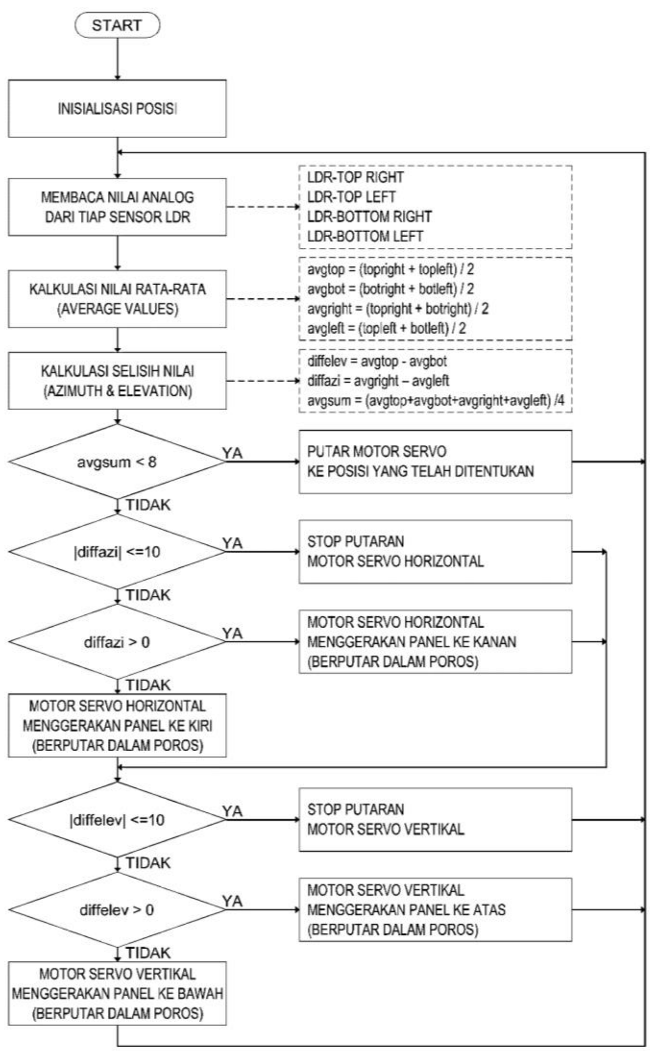

Figure 2. Flowchart solar tracking system

Hardware design

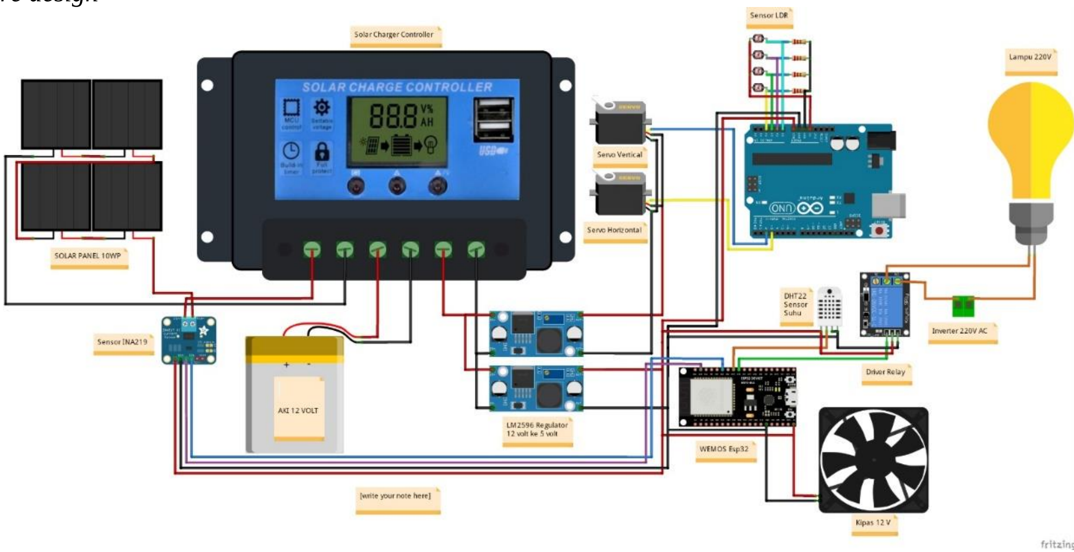

Figure 3. Schematic of monitoring and solar tracking system

Figure 3 above the monitoring system is the input section, when the system is activated the DHT-11 Humidity sensor will measure the temperature and humidity of objects on the solar panel which has an analogue voltage output, and the PZEM-004T V3.0 sensor which will measure power, voltage, current and the energy generated by the solar panels, which are then further processed using the Node MCU ESP8266 and all data is stored and read via the internet (Blynk Cloud). In the process section, the DC 5V 2A Power supply (Adapter) will provide power to the Node MCU ESP8266 microcontroller which will process data from the DHT-11 Humidity sensor and PZEM-004T V3.0 sensor. All data results are displayed digitally via the Blynk application via Blynk Cloud. In the output section, the value obtained from the sensor will be sent to Node MCU ESP8266 and then forwarded to the Relay Module to turn on or turn off the load (led light) and monitor the condition of the solar panels (Hassan, 2019; Oma et al., 2018).

The figure 3 above, the solar tracker system, input consists of 3 types, namely the LDR light sensor as a sensor to capture sunlight, then a push button switch as an automatic or manual mode button and also an axis selection mode in setting the position of the solar panel, push button switch-1 (as an automatic/manual mode) in automatic mode the solar panel will follow the movement of the sun while in manual mode the position of the solar panel can be adjusted manually via the potentiometer, then push button switch-2 (as the axis/servo selection mode which will be positioned) then there is a potentiometer that serves to adjust the angle. Then the three inputs are processed by Arduino Uno and then Arduino Uno provides output to the servo motor which serves as output so that the servo motor moves and changes angles according to the output given by Arduino Uno (Kondaveeti et al., 2021; Omran et al., 2022).

Software design

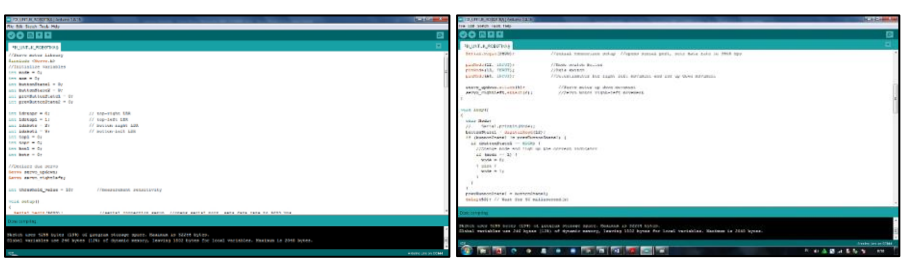

Figure 4. Programming NodeMCU ESP 8266 and Arduino Uno R3 in the Arduino IDE Application

The coding process is carried out using the default software from Arduino. This software is usually called Arduino IDE (Integrated Development Environment). IDE is a microcontroller application starting from writing the source program, compiling, uploading the compilation results and testing it on a serial terminal (Amarudin et al., 2020). In the Arduino software (IDE) a conventional tracker program is written as shown in Figure 4 above. This conventional tracker program generally contains naming, initializing, selecting data types, and giving logic to sensors and motors. The sensor used is LDR, while the actuator is a servo motor. The sensors are integrated into the Arduino program by passing through the analogue pins. Servo motors are integrated into the Arduino program by bypassing the PWM pins. This pin serves as a link between the programs listing from the LDR to the servo motor. In conventional program listings, the logic for the movement of the servo motor is given based on the input from the LDR. A monitoring system that can be accessed via the Blynk application on an Android smartphone (Jatmiko et al., 2020).

3 Results and Discussions

3.1 Design result

This research is expected to create monitoring of voltage, temperature and humidity generated on solar panels that can send warnings in real-time and can be accessed via the internet, both computers and smartphones. In this study, procedures were carried out to design and identify the results of monitoring voltage, temperature and humidity values generated by solar tracker devices and installed sensors based on the Internet of Things (IoT) with NodeMCU and Arduino Uno R3, shown on figure 5 below. The problem factor is the design of the tool and online parameter measurement via smartphone (Tewari & Gupta, 2020). The supporting documentation is then revised to further design the design to conform. After the device design is completed, the software is designed to read data from three sensors. Further tests will be carried out. If it can display data and is detected on the smartphone, it will be able to function normally. However, if it cannot be read and sent online, a hardware and software redesign of the solar tracking device and sensor will be redesigned (Nsengiyumva et al., 2018; Kelly & Gibson, 2009). The most influential solar cell parameter on the current-voltage characteristic curve.it is necessary to take into account the fact that the installed efficiency will depend on the operating temperature of the module, radiation level, radiation spectrum, wind speed and angle of incidence, as well as several other factors (Asrori & Yudiyanto, 2019).

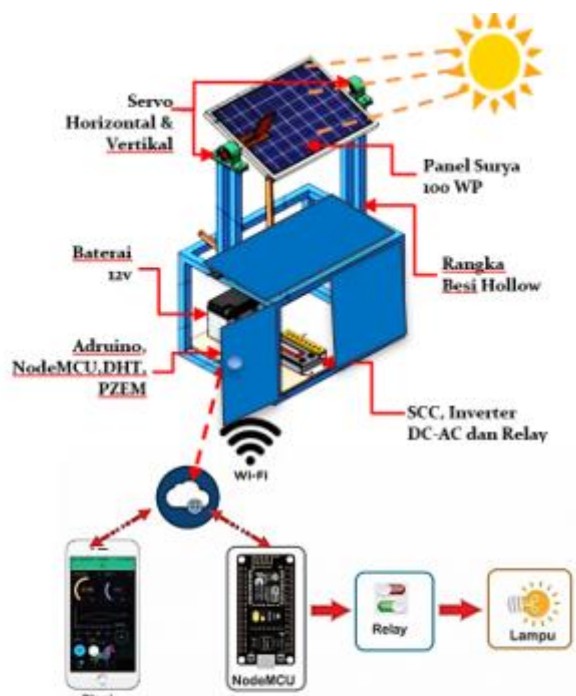

Figure 5. Design of IoT-based solar panel monitoring and solar tracking system

3.2 Hardware Build Result

The result which LDR sensor is placed at the top right corner of the solar panel. If the LDR sensor or light sensor around the solar panel is exposed to sunlight, the sensor will give a signal to the microcontroller to drive the motor (Munadi et al., 2019). Each sensor is given a partition to provide a shading effect when the position is not perpendicular to the sun, from this condition the sensor gives a signal to the Node MCU Microcontroller. NodeMCU is an open-source IoT platform that uses the Lua programming language to assist in making prototypes of IoT products or you can use sketches with the Arduino IDE (Prihasworo et al., 2021). Microcontroller gives directions to move the servo motor to follow the direction of the sun's rays shown in Figure 6 below.

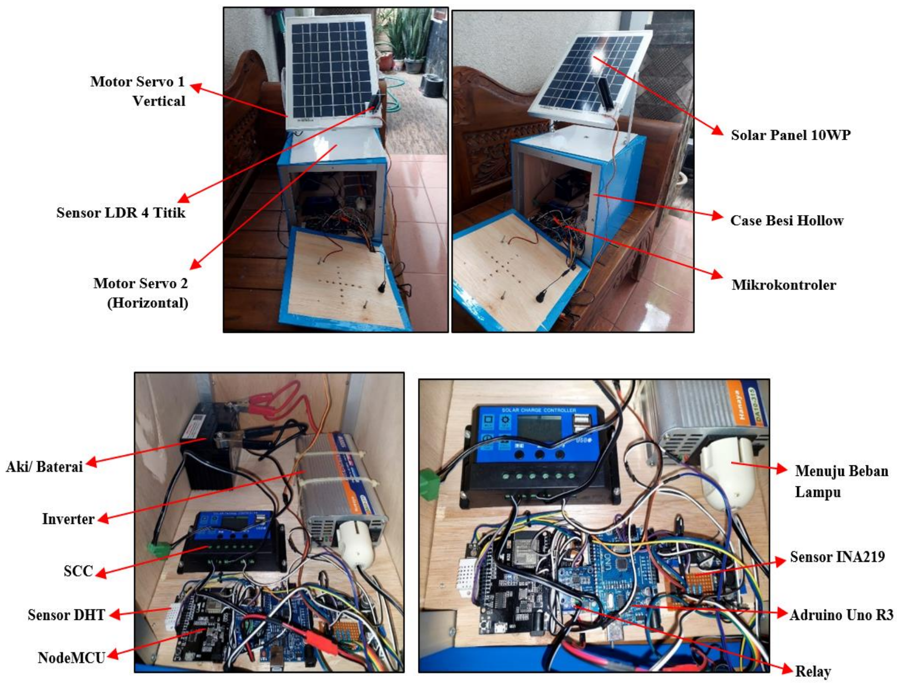

Figure 6. Hardware monitoring and *solar tracking* system

Figure 6 above, the INA219 sensor receives voltage data and the DHT11 sensor receives temperature data which is displayed via a smartphone on the BLYNK application. The components are assembled and programmed within 2 months using the Arduino Ide application. Using Node MCU to read the sensor, this microcontroller already has a WiFi module on the chip so it is very supportive for creating IoT application systems (Muliadi et al., 2020). Figure 6 displays the components that have been assembled and placed in the casing box, consisting of Node MCU, DHT11 Sensor, Battery/Battery, SCC, INA 219 Sensor, Arduino Uno R3 and Relay. The installation cable to the lamp load is separated from the outside of the casing (Bento, 2018).

3.3 Software Build Result

The results of the software design in this study using the Blynk IoT application appear as shown in Figure 7.

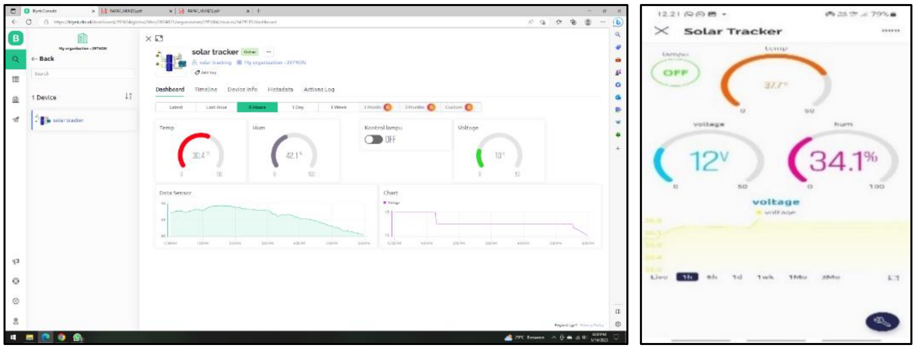

Figure 7. Result from Blynk App. Display on Komputer and Smartphone

3.4 Tool Testing Result

Based on meteorological data, testing of the monitoring and solar tracking system on Internet of Things (IoT)-based solar panels was carried out in the Pedungan sub-district, South Denpasar sub-district, Denpasar city for one week to obtain data on voltage, temperature, humidity and servo motor movement. The results of each test for 1 week explained that the tool was installed starting at 08.00 and running smoothly until 18.00, after that the graphs began to be read on the Blynk application online with computers and smartphones as WIFI signalers from the host to the computer's online WIFI. The process of transferring data online, namely the internet, must be in a stable state to avoid the system running out of data when the device is working (Kashyap et al., 2018; Kalia & Ansari, 2020).

But after a while, there is some inaccurate data on the Blynk app. Then the day is checked with the device's WIFI system. After this is done, the monitoring system on the Blynk and the servo motor is removed and then reconnected so that it runs normally. From this trial, it can be seen that the battery can be charged properly as long as there is sunlight. The battery can last for 8 hours to turn on the 20 watts of the lamp, counting from 19.00 WITA until the sun rises at 06.00 WITA.

Figure 8. Testing Monitoring and *Solar Tracking* System

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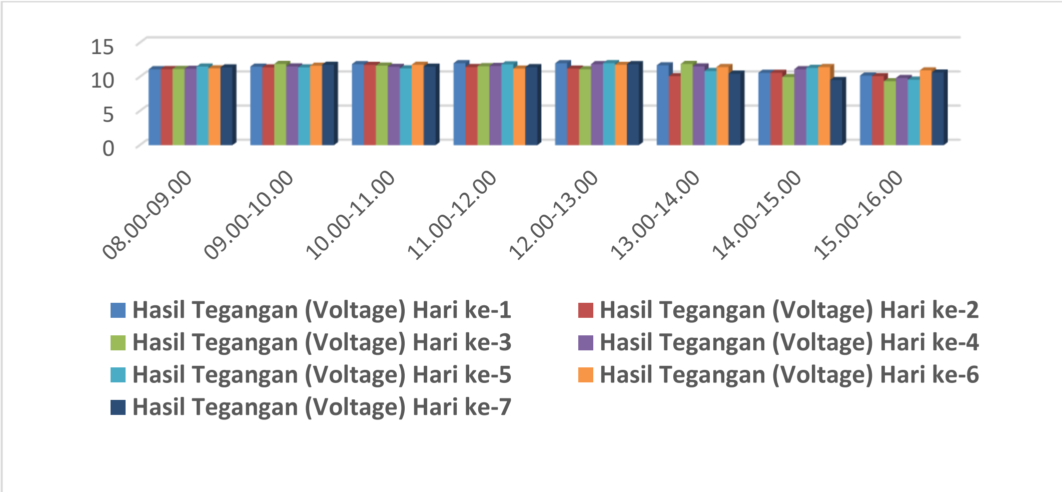

Figure 9. Comparison of Voltage Results in 1 Week (Time: 08.00 to 16.00 WITA)

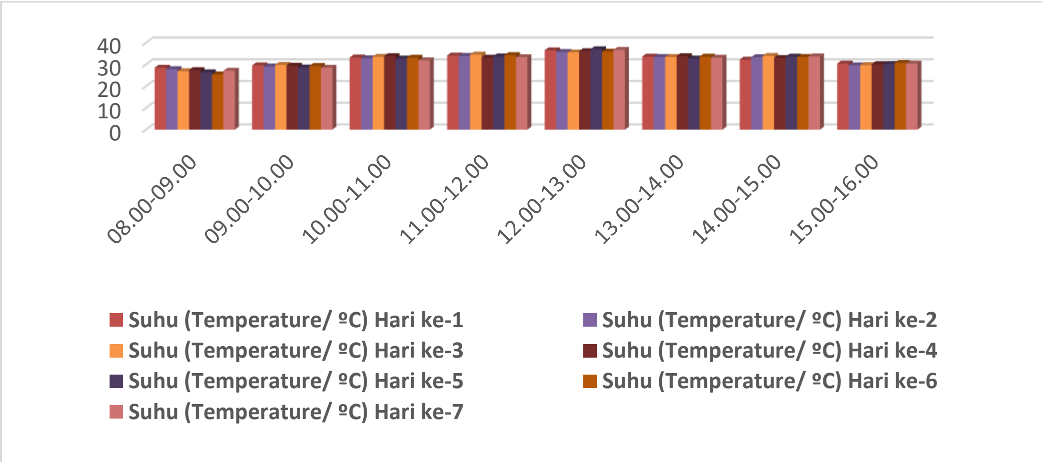

Figure 10. Comparison of Temperature Results in 1 Week (Time: 08.00 to 16.00 WITA)

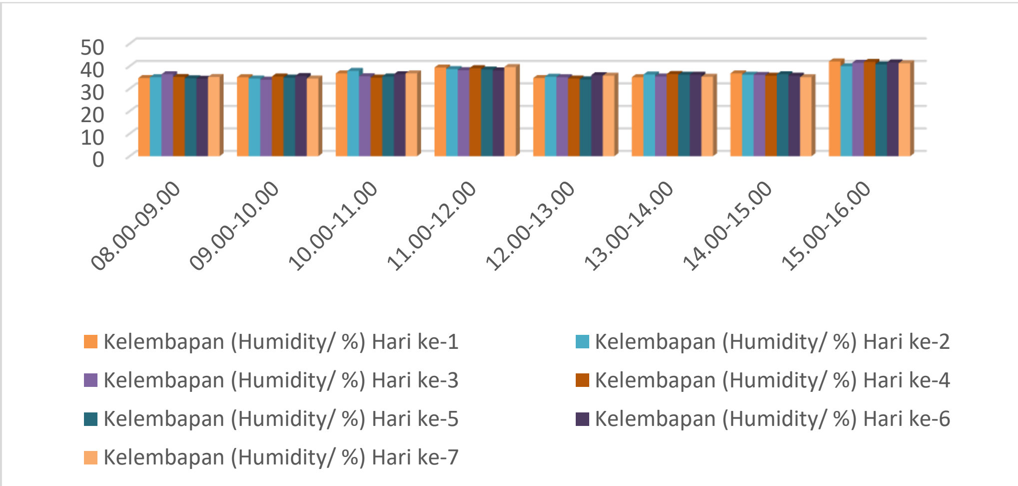

Figure 11. Comparison of humidity results in 1 week (Time: 08.00 to 16.00 WITA)

Table 1
Output power from solar panel

Time	Solar Tracker (W)	Without Solar Tracker (W)	Comparison
08.00-08.30	21,30	21,28	0,02
08.30-09.00	23.49	23.43	0.06
09.00-09.30	23.56	23.51	0.05
09.30-10.00	23.23	22.19	1.04
10.30-11.00	23.31	22.25	1.06
11.00-11.30	23.80	22.71	1.09
12.00-12.30	23.87	22.73	1.14
12.30-13.00	23.81	22.61	1.20
13.00-13.30	23.90	21.76	2.14
13.30-14.00	23.67	20.53	3.14
14.00-14.30	23.72	17.49	6.23
14.30-15.00	2.44	0.34	2.10
15.30-16.00	23.32	20.19	3.13
16.00-16.30	5.12	2.04	3.08
16.30-17.00	4.41	2.36	2.05
17.00-17.30	2.83	1.73	1.10
17.30-18.00	1.88	1.81	0.07

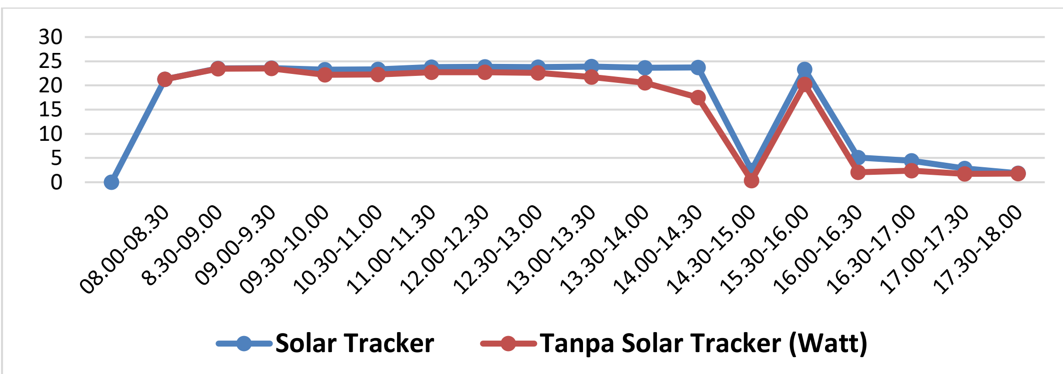

Figure 12. Comparison of output power

Table 1 above is the average of the power values that have been taken at 08.00 to 18.00 WITA. From the average power generated between solar panels with a solar tracker and without a solar tracker, it can be concluded that solar panels with a solar tracker can issue a greater power output than those without a solar tracker. The biggest difference in power occurs at 14.00 – 14.30 WITA. The big difference reaches 6.23 Watts. Increasing the performance of solar panel power is obtained by calculating the average difference divided by the fixed average and multiplied by 100%. Based on the calculation results, the increase in power performance from solar panels using a 20 Watt load is 10.67%.

Based on Figure 12, it can be seen that the overall power output of the solar panel tracker is greater than without a solar tracker. At 08.30-09.30 and 17.30-18.00, the power output of solar panels with and without a solar tracker is relatively the same. This is because some of the sunlight is blocked by objects in the environment around the measurement. Under these conditions, the light received by solar panels with a solar tracker and without a solar tracker. As a result, the output power of the two solar panels is also relatively the same.

4 Conclusion

Based on the design and data analysis that has been done, it can be concluded that the design of the monitoring system and solar tracker system is successful and can increase the output power of the solar panels. There are problems with NodeMCU and the ESP 8266 wifi system in the signal for online and scalable data transfer. Overall, the power output generated from the tracker is greater than without a solar tracker. The biggest difference in power between a solar tracker and without a solar tracker is 6.23 watts using a 20 Watt load of LED lights. The performance increase obtained was 10.67%.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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