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PV Energy Monitoring and Optimization System with IoT

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A R T I C L E I N F O

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A B S T R A C T

The efficiency of converting sunlight energy into electrical energy which was previously felt to be less effective to be more effective, it is one of the objectives of this study in addition to problems regarding the direction of solar panel trackers which sometimes do not effectively point to the sun so that the energy obtained is less than optimal, then a two-way communication system is made so that it can control and monitor trackers via the internet or what we often know as the Internet of Things (IoT) system. For the research method that researchers use is the research and development method, as a link between the tool and the monitoring system here firebase is used as a database, so that all parameter values in the tool are sent to the database which is then processed and will be displayed on the monitoring website, besides that for control works the other way around, from the website will send a signal to the firebase database which is then forwarded to the tool, we think this is very helpful and simplifies both monitoring and controlling tools in the form of solar panel trackers.

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INTRODUCTION

Since 2018, the growth of New Renewable Energy (EBT) in Indonesia has increased by an average of 4.3% each year, as reported by www.liputan6.com published on 11 Feb 2023, 08:15 WIB this average increase has not been able to meet the target set in 2025, the development of renewable energy in Indonesia is still not satisfactory so efforts are needed to accelerate the utilization of New Renewable Energy (Fajar Fadli, 2021). But on the other hand, there are often problems in the field regarding the efficiency of energy produced by solar power because the direction of solar panels is not always right towards the sun, because the angle between solar panels and the sun greatly affects the energy output of solar panels. Therefore, to get maximum efficiency from sunlight, solar panels must always be in a position facing the direction of sunlight. With the knowledge of the earth's rotation, the location of the sun is not always the same at all times. At any given time, the sun is in the northern hemisphere, sometimes in the southern hemisphere or on the equator, As a result solar cells are not able to absorb maximum solar energy due to changes in the position of the sun at each time. To get maximum efficiency, the solar panel must follow the movement of the sun. The position of solar cells towards the sun must be controlled automatically based on the direction of the sun using a solar cell module drive using microcontroller instrumentation system technology (Qory, et al. 2020) (Syahab, et al. 2019). But after the tracker is installed on the solar panel, the question of the tool usually directs the panel to the sun only based on the LDR sensor and voltage sensor based on the voltage value, and this LDR sensor itself in some circumstances often has errors because the process occurs open loop, so that if there is an error in reading the direction of the sun, it makes the efficiency of the solar panel remain less than optimal, here it takes a precise sensor reading process and must be processed first in a close loop so that if there is a reading error on the sensor, it can be easily and quickly resolved by the artificial intelligence embedded in the server, so that not only one or two trackers can be controlled but up to hundreds to thousands of trackers, it all depends on the capacity of the server that we make, From here we can imagine the ease of monitoring and control (Budiartono, et al. 2019) of PLTS fields throughout Indonesia, so that if there is damage the technician does not need to come to the location but only needs to check it through the application or website that we have made, if it requires action then only the technician comes to the location.

LITERATURE REVIEW

In this section, researchers conducted a literature review by studying a number of references that are relevant and needed to strengthen this research, namely as follows, Energy is the ability to do work. Energy is power that can be used to carry out various activity processes including mechanical energy, heat, and others. Therefore, almost all disputes in this world stem from the struggle for energy sources. There is some natural energy as an alternative energy that is clean, non-polluting, safe and unlimited supply known as renewable energy. Solar energy is a very good energy to be developed in Indonesia. This is because Indonesia is one of the countries located on the equator. Solar energy that can be used for all of Indonesia's land with an area of 2 million km2 is 4.8 kWh/m2 in

one day, equivalent to 112,000 GWp (Hasrul, 2021) (P. S. Ningsih, 2020). Therefore, renewable energy in the form of solar energy is very suitable for use and development in areas such as Indonesia. The system design and some of the tools needed to build an efficiency enhancing tool this time are Frame Design, For this tool has an important part, namely a tracker for solar panels with dual axiz movements, it is hoped that this tracker can position solar panels so that they point exactly in the direction of sunlight so that the energy obtained from the sun is maximized, then for control can be done manually or automatically using the help of an Arduino microcontroller, and for monitoring and control will be made two-way communication via the internet so that the tool can be monitored and controlled remotely (Eteruddin, et al. 2020).

Figure 1. Device Schematic

Then for the database researchers use Firebase, which is a service from Google to make it easy and even easier for application developers to develop their applications. Firebase aka BaaS (Backend as a Service) is a solution offered by Google to speed up developer work. By using Firebase, app developers can focus on developing applications without putting a lot of effort into backend matters.A short story about the history of Firebase was first established in 2011 by Andrew Lee and James Tamplin. Firebase's first product was Realtime Database. Realtime Database is used by developers to store data and synchronize to many users. Later it evolved as an app developer service. In October 2014, the company was acquired by Google.In terms of services, Firebase used to provide trial services, but now Firebase can be utilized and used for free. Of course, with certain limitations.

There are 2 choices of services available from Firebase, including:

- SPARK: we can use the service for free.
- BLAZE: we will be charged according to service usage.

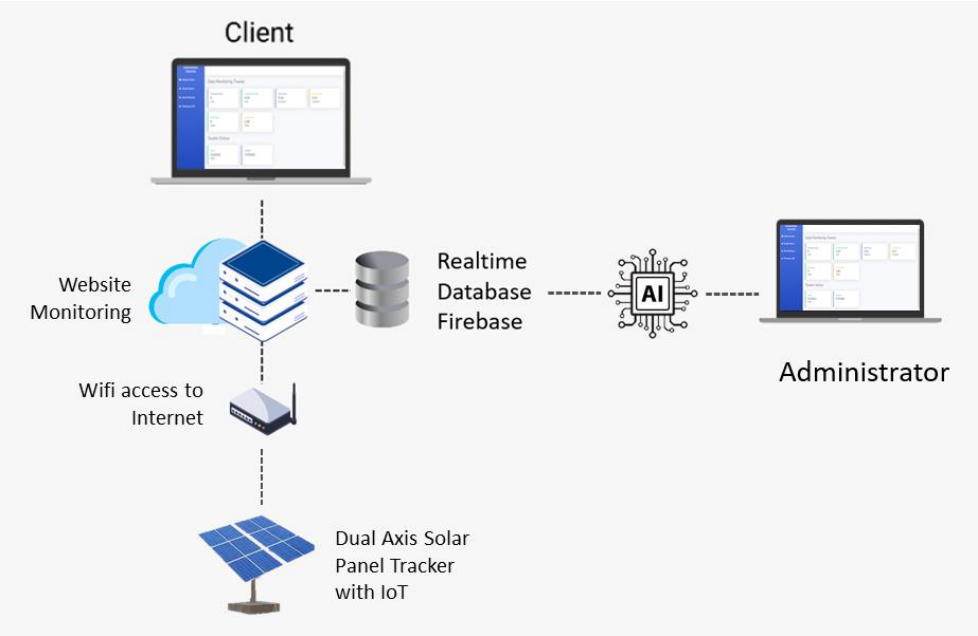


Figure 2. Device Schematic

METHODOLOGY

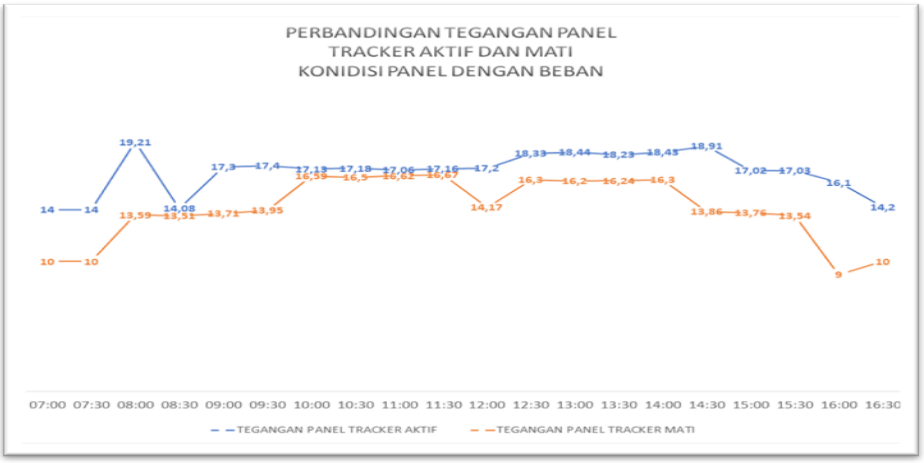
For the method used, namely the research and development method, namely trying and seeing the quality produced after the experiment is carried out, for the data collection process is carried out by trying the tool directly in order to get the real value of the original situation, after the data is obtained, it will be compared with the previous data value whether there is a change or not, if there is a change, it is also determined whether the change is good or bad, if the change is for the better, the results are considered successful, for data values can be seen on the monitoring website page.

RESULTS

The results of this test are carried out to compare the voltage value when the tracker is on and off with a baban in the form of a DC lamp, with this lamp load, researchers can see whether the voltage will drop or decrease in voltage or not, because in theory the voltage on the panel will decrease when a load is attached, besides the influence of less bright sunlight will result in a more severe voltage drop due to the panel being given a load.

Table 1. Voltage Data Table With Tracker on and Off with Load

	TEGANGAN PANEL TRACKER AKTIF	TEGANGAN PANEL TRACKER MATI
07:00	14	10
07:30	14	10
08:00	19, 21	13,59
08:30	14, 08	13,51
09:00	17,3	13,71
09:30	17,4	13,95
10:00	17, 13	16,59
10:30	17, 18	16,5
11:00	17, 06	16,62
11:30	17, 16	16,67
12:00	17,2	14,17
12:30	18, 33	16,3
13:00	18, 44	16,2
13:30	18, 23	16,24
14:00	18, 43	16,3
14:30	18, 91	13,86
15:00	17, 02	13,76
15:30	17, 03	13,54
16:00	16,1	12
16:30	14,2	10
17:00	14	10



Picture 3. Voltage Data Graph Drawing with Tracker on and Off with Load

It can be seen in the picture above that when the tracker is active the resulting voltage tends to be more sloping like no load but even though the load here the resulting graph is still sloping, this indicates that the absorption of light energy from sunlight is more optimal and can produce greater energy, otherwise when the panel is at rest or the tracker is off, the resulting voltage tends to be more unstable and up and down which results in energy absorption being less than optimal. At this point, researchers can conclude that the tracker works well in the position of the panel under load. Furthermore, researchers compare with the data before the tool is made or the tracker is made.

Table 2. Data Table Before the Tool is Made

	Tegangan Dengan Beban	Tegangan Tanpa Beban
Jam 07,00	10	10
Jam 08,00	10	12
Jam 09,00	11	13
Jam 10,00	13,5	17
Jam 11,00	15	17,5
Jam 12,00	16	17
Jam 13,00	15	16
Jam 14,00	16,5	17,6
Jam 15,00	16	16
Jam 16,00	13	14
Jam 17,00	10	10

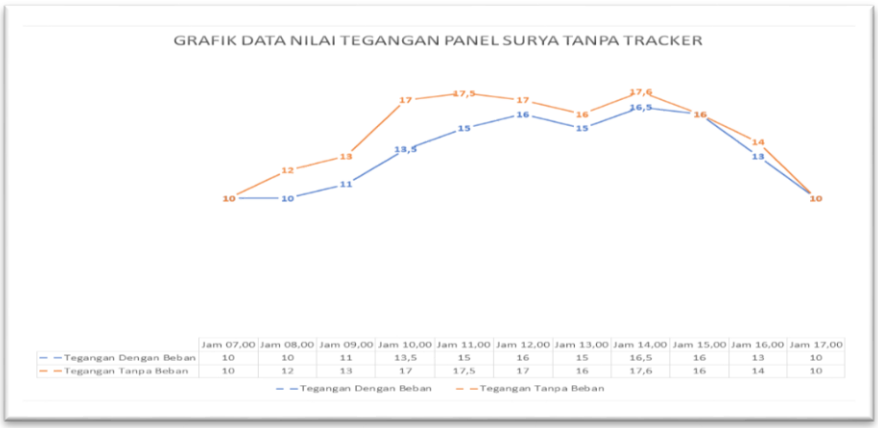


Figure 4. Graphical Image of Data Before the Tool is Made

The graph above is a voltage graph before the tool is made, the researcher focuses on the blue line, which compares with the panel when given a load, on the graph it can be seen that the voltage is more unstable marked by the formation of a fairly sharp climb and descent of the graph, besides that the voltage value is also below the voltage value without load, maybe this is because the panel is only facing up and when testing before the tool is made only using a cable with a small diameter so that the voltage drops quite large, this has been overcome after the tool is made.

DISCUSSION

From the data that has been obtained from the test results, it is found that the correct voltage value is affected by the direction of the panel towards the sun so that when the solar panel is pointing right towards the sun, the voltage value obtained is the best voltage value, besides that the load value also affects the magnitude of the charger voltage value to the battery and the voltage to the load, the greater the value of the load used, the greater the voltage drop value, so we must consider between the value of the capacity of the solar panel must be balanced with the load value, for ease of monitoring this is good enough, so that it can be used to monitor the value of the value in the solar panel so that we do not need to come directly besides that the ease of controlling the tool is also well used to support the reliability of this system.

CONCLUSIONS AND RECOMMENDATIONS

The conclusion that can be drawn is that the voltage value produced by the panel in the active tracker position is better than in the off tracker position, this can be seen in the voltage graph 4.51, which previously had a voltage in the range of 15 Volts to 19 Volts so that the voltage is more stable and of higher value, so it can be concluded that solar panels with trackers are better than panels without trackers. then for the communication system using the firebase database, researchers think it is very good if it is further developed, for now the tool can only monitor the tool, control the tool, and record the actual data if explored more deeply this tool can be collaborated with IoT in other sectors.

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