# System Design Renewable Energy Using Applications Bright Energy Solar Meter Panel Based on The Internet of Things

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**Abstract.** Energy consumption is increasing worldwide. Dwindling fossil fuel resources and increasing greenhouse gas emissions have fueled global interest in alternative energy systems. One of the potential renewable energy sources in Indonesia is solar energy because Indonesia is located on the equator, which has abundant solar energy sources with an average solar radiation intensity of around 4.8 kWh/m2 per day throughout Indonesia. In the solar power generation system, batteries are needed for power storage, and tools are needed to monitor the input and output power of the solar panels. Therefore, we need a tool that can monitor the use of electric power directly, which can be monitored remotely using an Android application through the IoT system. The system will be made using an ESP32 microcontroller board that is equipped with a WiFi module that has two input components, namely the PZEM-004T sensor and INA219 to detect the input voltage from the solar panel and the PZEM-004T INA219 sensor to detect the output voltage used. Data will be sent to Firebase and connected to the smartphone application. Has a relay output to control the resource from solar panels to electrical energy that is issued from the PLN, and the LCD functions to display the results of the parameter readings being tested. In the final stage of testing, it is planned to produce research in the form of a tool that is ready to be tested, targeting solar panel users to be able to monitor and control solar panels efficiently and easily.

**Keywords:** Solar panels, smart energy, microcontroller, efficiency, real time.

## 1 Introduction

Energy consumption is increasing worldwide. Dwindling fossil fuel resources and increasing greenhouse gas emissions have fueled worldwide interest in alternative energy systems [1]. The current use of electric power only uses a kWh meter to see the power distributed by PLN (State Electricity Company). These tools cannot provide detailed information about how much electricity is being used. This can lead to the wastage of electricity because there is no direct supervision of electricity consumption.

One of the potential renewable energy sources in Indonesia is solar energy because Indonesia is located on the equator, which has abundant solar energy sources with an


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average solar radiation intensity of around 4.8 kWh/m2 per day throughout Indonesia [2]. To find out current and voltage conditions in PLTS, you usually have to check them manually using a multimeter. In the solar power generation system, batteries are needed for power storage, and tools are needed to monitor the input and output power of the solar panels. Therefore, we need a tool that can monitor the use of electric power directly, which can be monitored remotely using an Android application through the IoT system [3].

In this research, a current and voltage monitoring system was designed by utilizing a voltage sensor as a source voltage meter, a relay to function as a source switch, the INA219 sensor as a DC current and voltage meter, the PZEM-004T sensor as an AC current and voltage meter, and the ESP32 as a microcontroller. To monitor the value of the sensor, this research will use a Google database with the name Firebase as a temporary sensor data storage where sensor value readings can be done in real time and an Android application created using Android Studio software to read and display sensor values from the database [4].

# 2 Research Method

## 2.1 Solar Panel Energy

Solar energy is an unlimited source of energy, and its availability will never run out. This energy can also be used as alternative energy, which will be converted into electrical energy using solar cells. Solar panels as an alternative source of electrical energy can be utilized by people who need electrical energy but are constrained by the unavailability of electrical energy. Solar cells arranged in series will produce a voltage of around 16V. [5] This voltage is enough to be used to supply a 12V battery. In simple terms, the way solar panels work is by absorbing sunlight and storing the resulting energy in a battery. Thus, the system can run even in the afternoon, at night, or during rainy conditions. In addition, there is a cable that is integrated with the electrical installation in the house. When there is electricity consumption from electronic goods, for example, when turning on a television, the electricity is automatically taken from the battery.

## 2.2 Wireless Communication

Wireless Communications is the transfer of information between two or more points that are not connected by an electrical conductor. Distances can be short, such as a few meters for television remote control, or as far as thousands or even millions of kilometers for deep-space radio communications. This includes various types of fixed, mobile, and portable two-way radios, cell phones, personal digital assistants (PDAs), and wireless networks. Wireless network (2.4 GHz) is used to fulfill many needs [6]. Perhaps the most common use is to connect laptop users who travel from location to location. Another common use is for mobile networks connected via satellite. Layers of wireless communication can be seen in Fig. 1. In this study, all layers in the image will be used to convey information.

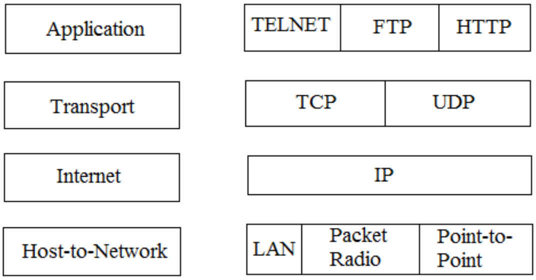



**Fig. 1.** Wireless Communication Layer.

## 2.3 Internet of Things

Internet of Things (IoT) is a concept/scenario where an object has the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The term IoT (Internet of Things) became known in 1999 when it was first mentioned in a presentation by Kevin Ashton, cofounder and executive director of the Auto-ID Center at MIT. IoT has been in development for decades. The first Internet tool, for example, was the Coke machine at Carnegie Melon University in the early 1980s. Programmers can connect to machines via the Internet, check the machine's status and determine whether or not a cold drink is waiting for them, without having to go to the machine. Fig. 2 shows a picture of the development of the internet of things. [7]


**Fig. 2.** Internet of Things System.

## 2.4 System Design

Research stages Title System design & implementation Renewable Energy Smart Energy Meter Application Using Internet Of Things-Based Solar Panels is made to detail each stage of making the tool until testing is carried out so that the results are obtained sequentially. The research design to be carried out in making the system is shown in Fig. 3.

As can be seen in the Fig. 4, the main microcontroller uses an ESP32 board equipped with a WiFi module which has 4 input components, namely 3 INA 219 sensors to detect the input voltage from the solar panel, to detect the voltage to the battery, and to detect the output voltage from the battery to the inverter. PZEM-004T sensor to detect the output voltage load used. Data will be sent to firebase and connectivity with the smartphone application. Has a Relay output to control the on/off switch from the solar panel at night or overcast. Smartphone to display the results of the parameter readings being tested. How the smart meter works is that when the system is running, it automatically measures the voltage that is obtained from the solar panel, the voltage that can go to the battery, the level of battery power (%), and what load is used (V, W, A), which will be displayed on the smartphone through the application that was created and can be monitored remotely.

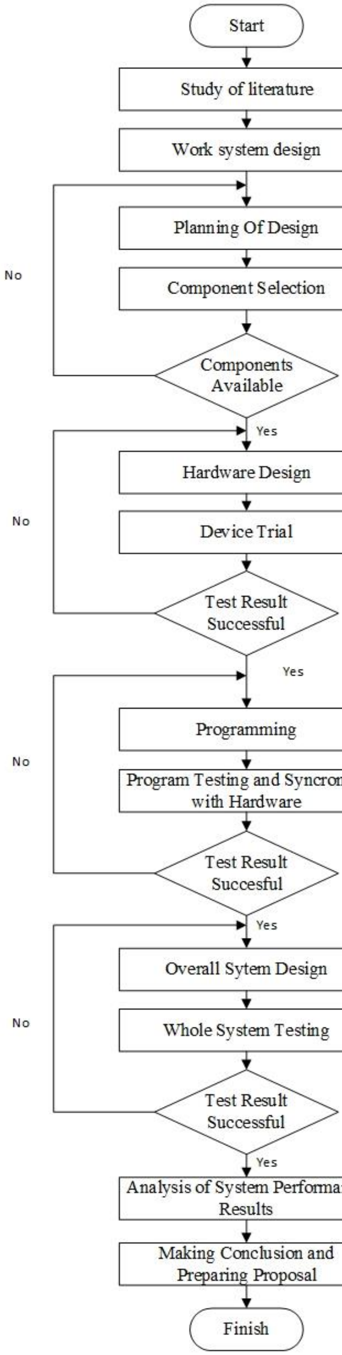



**Fig. 3.** Research Flowchart

In the event of a heavy load surge and when the solar panel's ability to absorb sunlight is not optimal, it automatically switches to using PLN to charge the battery and always tries to keep the battery at > 50%. For the IOT system used in this tool, it can monitor the input voltage and load used and switch PV to PLN or vice versa remotely using the internet, which is connected to the database through the application. This test starts with sensor readings, and then microcontroller processing processes the results from sensor readings so that the value of sensor readings can be seen via a smartphone.

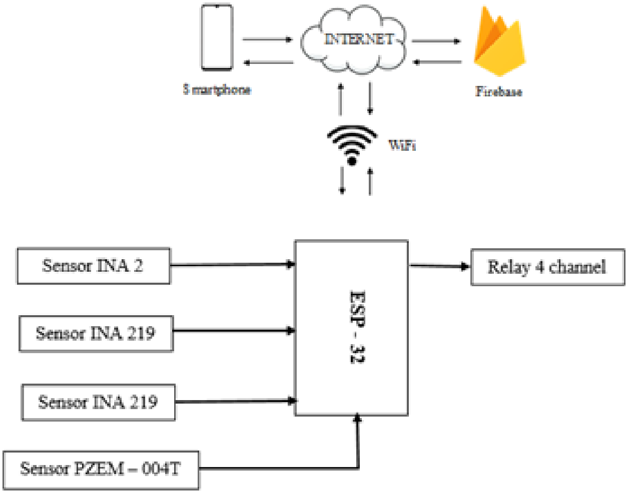


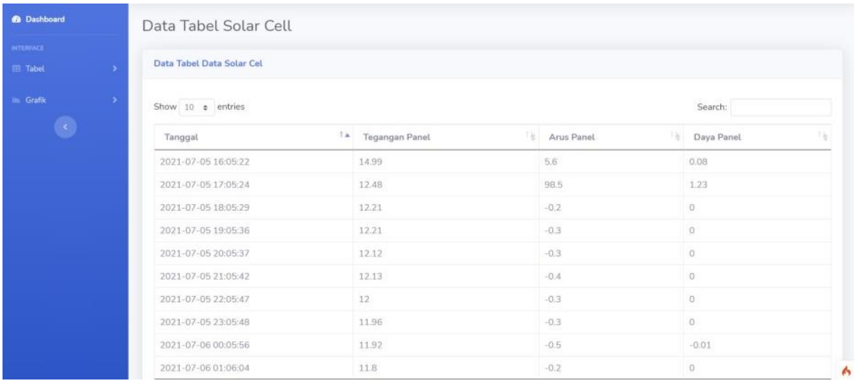

**Fig. 4.** System Block Diagram

## 3 Result and Discussion

This section will describe the production of electrical energy generated by the hybrid power generation system, the consumption of electric power and the excess of residual electrical energy of the different systems and schemes. Solar panels and installed tools are shown in Fig. 5 below. Installation is done separately where the solar panels are outside or on the roof of the building. while the system, made with sensors and a microcontroller, is installed under the roof so that it does not get too hot in direct sunlight. On system, There is a DC voltage and current sensor INA-219 which is connected to the solar cell and battery. The PZEM-004T power sensor is connected to the load which is used to see voltage, current, power, power factor and frequency.


**Fig. 5.** Impelementation System anda Solar Panel

in Fig. 6 displays tabular data on the web made in the form of no, formatted date (year-month-date hours-minutes-seconds), Voltage values in units of Volts (V), Currents in units of milli Ampere (mA), Power in units Watts (W), and light intensity in lux units.




| Tanggal | Tegangan Panel | Arus Panel | Daya Panel |
|---|---|---|---|
| 2021-07-05 16:05:22 | 14.99 | 5.6 | 0.08 |
| 2021-07-05 17:05:24 | 12.48 | 98.5 | 1.23 |
| 2021-07-05 18:05:29 | 12.21 | -0.2 | 0 |
| 2021-07-05 19:05:36 | 12.21 | -0.3 | 0 |
| 2021-07-05 20:05:37 | 12.12 | -0.3 | 0 |
| 2021-07-05 21:05:42 | 12.13 | -0.4 | 0 |
| 2021-07-05 22:05:47 | 12 | -0.3 | 0 |
| 2021-07-05 23:05:48 | 11.96 | -0.3 | 0 |
| 2021-07-06 00:05:56 | 11.92 | -0.5 | -0.01 |
| 2021-07-06 01:06:04 | 11.8 | -0.2 | 0 |

**Fig. 6.** Solar Cell Table Website

System test was carried out to find out how much power a solar cell can generate from 06.00 to 17.00 with data collection for 3 days of testing. The data obtained was then analyzed, and the average power generated during the experiment was calculated. The following are the results of data collection for voltage, current, and power in the solar cell. Result from test shown on Table 1.

**Table 1.** Voltage, Current, and Solar Cell Power

| No | Date | Time on PM | Volt (V) | Current (mA) | Power (Watt) |
|---|---|---|---|---|---|
| 1 | Saturday 22/04/2023 | 6 | 11,7 | 119,2 | 1,4 |
| 2 | | 7 | 12,57 | 725,9 | 9,13 |
| 3 | | 8 | 13,24 | 1291,1 | 17,09 |
| 4 | | 9 | 13,4 | 1330,4 | 17,82 |
| 5 | | 10 | 13,63 | 1406,7 | 19,17 |
| 6 | | 11 | 13,69 | 1428,1 | 19,55 |
| 7 | | 12 | 14,6 | 2499 | 36,48 |
| 8 | | 13 | 14,21 | 1624,3 | 23,08 |
| 9 | | 14 | 14,08 | 1423,2 | 20,03 |
| 10 | | 15 | 13,47 | 857,1 | 11,55 |
| 11 | | 16 | 12,94 | 549,1 | 7,1 |
| 12 | | 17 | 11,74 | 46,8 | 0,54 |
| **Average** | | | **13,27** | **1108,4** | **15,24** |
| 13 | Sunday 23/04/2023 | 6 | 11,55 | 336,2 | 3,77 |
| 14 | | 7 | 12,3 | 650 | 7,99 |
| 15 | | 8 | 12,66 | 936,7 | 11,858 |
| 16 | | 9 | 12,82 | 1444 | 18,52 |
| 17 | | 10 | 13,45 | 1847,5 | 24,84 |
| 18 | | 11 | 14,4 | 3200 | 46,08 |
| 19 | | 12 | 14,82 | 3200 | 47,42 |
| 20 | | 13 | 14,78 | 3200 | 47,29 |
| 21 | | 14 | 14,27 | 1671,2 | 23,84 |
| 22 | | 15 | 13,42 | 1545,2 | 20,73 |
| 23 | | 16 | 12,4 | 603,4 | 7,48 |
| 24 | | 17 | 11,76 | 47,3 | 0,55 |
| **Average** | | | **13,21** | **1556,79** | **21,69** |
| 25 | Monday | 6 | 11,64 | 318,1 | 3,7 |

| No | Date | Time on PM | Volt (V) | Current (mA) | Power (Watt) |
|---|---|---|---|---|---|
| 26 | 24/04/2023 | 7 | 13,68 | 809,7 | 11,07 |
| 27 | | 8 | 13,69 | 1692,1 | 23,16 |
| 18 | | 9 | 14 | 3025,8 | 42,36 |
| 19 | | 10 | 13,6 | 2315,4 | 31,48 |
| 30 | | 11 | 13,8 | 3182,9 | 43,92 |
| 31 | | 12 | 14,01 | 3200 | 44,83 |
| 32 | | 13 | 14,12 | 3200 | 45,18 |
| 33 | | 14 | 13,62 | 1374,7 | 18,7 |
| 34 | | 15 | 13,21 | 927,1 | 12,24 |
| 35 | | 16 | 12,89 | 770,3 | 9,92 |
| 36 | | 17 | 12,14 | 49,98 | 0,6 |
| **Average** | | | **13,36** | **1738,84** | **23,93** |

Table 1 shows the current, voltage, and power generated by the solar cell. The data obtained is every hour from 06.00 to 17.00. The data retrieved is stored and recorded in a cloud database connected to Domainsia Hosting. In the table, the average voltage value on Saturday was 13.27 V, for a current of 1108.4 mA, and the power was 15.24 watts. On Sundays, the average value of the voltage is 13.21 V, the average value of the current is 1556.79 mA, and the power is 21.69 watts. For Monday, the average voltage value is 13.36, the average current is 1738.84 mA, and the average power is 23.93. From these data, it can be determined that the highest power generated by the solar cell is on Monday, which is 23.93 watts, while the smallest power is on Saturday, which is 15.24 watts.

Fig. 7 shows the parameters of the solar cell on Saturday, April 22, 2023. From the graph above, it can be seen that the values of voltage, current, and power have relatively increased from 06.00 to 12.00, where the highest peak increase was at 12.00. Furthermore, during the period from 13.00 to 17.00, the graphs of voltage, current, and power decreased. The constant relative voltage value ranges from 11 V to 14 V. Meanwhile, the current value changes to a maximum value of 2499 mA.

Fig. 8 shows the parameters of the solar cell on Sunday, April 23, 2023. From the graph above, it can be seen that the relative voltage, current, and power values have increased from 06.00 to 12.00, with the highest peak increases occurring at 12.00. Furthermore, during the period from 13.00 to 17.00, the graphs of voltage, current, and power decreased. The relative constant voltage value ranges from 11 V to 13 V. Meanwhile, the current value changes to a maximum value of 3200 mA.

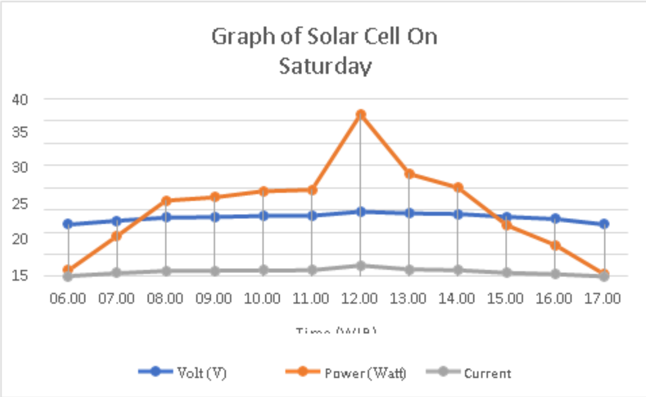



**Fig. 7.** Graph of Saturday Solar Cell Parameters

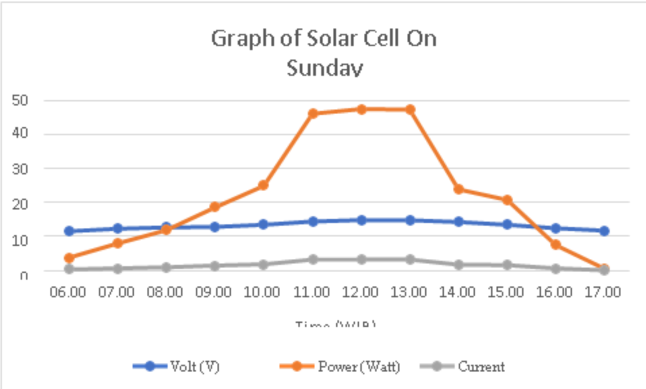



**Fig. 8.** Graph of Sunday Solar Cell Parameters

Fig. 9 shows the parameters of the solar cell on Monday, April 24, 2023. From the graph above, it can be seen that the values of voltage, current, and power have relatively increased from 06.00 to 12.00, where the highest peak increase was at 13.00, but the power value at 10.00 experienced a decline and rose again at 11.00. Furthermore, during the period from 13.00 to 17.00, the graphs of voltage, current, and power decreased, with the biggest decrease occurring from 13.00 to 14.00. The relative constant voltage value ranges from 11 V to 14 V. Meanwhile, the current value changes to a maximum value of 3200 mA.

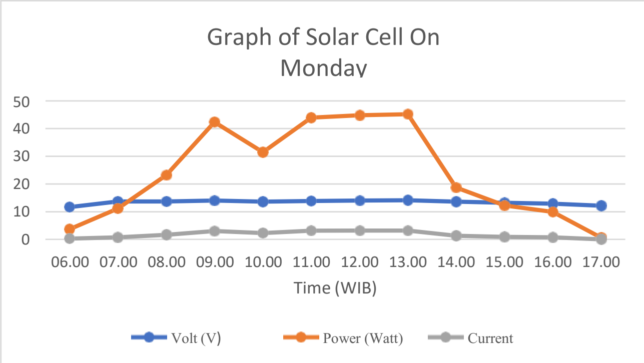



**Fig. 9.** Graph of Monday Solar Cell Parameters

## 4 Conclusion

The performance of solar cells during testing within 3 days, starting from Saturday, April 22, 2023, to Monday, April 24, 2023, from 06.00 to 18.00, produced an average power of 20.28 watts and an average value of sunlight intensity of 680062.32 lx. On Saturday, an average power of 15.24 watts was obtained with a maximum voltage of 12.00, which was 36.48 watts, and a light intensity value of 166400.21 lx. On Sunday, the average power is 21.69 watts with a maximum voltage of 12.00, which is 47.42 watts, and the intensity of sunlight is 169183.34 lx. For Monday, the average power obtained was 23.93 watts, with a maximum voltage of 13.00, which is 45.18 watts, and the intensity of sunlight being 158108.11 lx. From these data, it can be concluded that the higher the intensity of sunlight, the greater the power generated.

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