IFERP
ISSN (Online) 2394-6849
International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 10, Issue 1, January 2023

Data Acquisition and Monitoring System of Power Consumption Based on Web Services

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Abstract— ***Saving electrical energy is an obligation for campus operational activities. Based on the Regulation of the Minister of Energy and Mineral Resources Number 13 of 2012 concerning Efficient Electricity Consumption in State Buildings, the POLMED campus is obliged to carry out this mandate. For this reason, efforts are needed to support saving electricity. One of them is the use of alternative sources of electricity other than the primary source of electricity from PLN. This alternative source of electricity uses solar panels. The output of this device must be able to monitor its stability. The amount of power used must also be monitored to find out how much the savings are in terms of costs. This system must be able to acquire data and monitor the Power Consumed and the measurement results can be displayed in real time and can be accessed anytime and anywhere. This system uses IoT-based components to connect to the internet. The results of this study are expected to be a reference in managing electrical energy efficiency at the campus.***

Index Terms— ***saving electricity, solar panels, data acquisition, monitoring power consumption.***

I. INTRODUCTION

Saving electrical energy is a necessity for campus operational activities. Based on the Regulation of the Minister of Energy and Mineral Resources Number 13 of 2012 concerning Efficient Electricity Consumption in State Buildings, Office Homes, Public Street Lighting, Decorative Lights, and Billboards [1]. The campus of Politeknik Negeri Medan is one of the state-owned buildings. For this reason, the POLMED campus must carry out this mandate in all sections/units, namely academics, infrastructure, and buildings.

The building sector, such as study rooms, offices, libraries, laboratories, commercial premises, and workshops, requires the highest consumption of electricity. The utilization of air conditioners (AC) is the highest consumption of electrical energy (57%), lighting (19%), lifts and pumps (18%), and other equipment (6%) [2]. Energy consumption is often wasteful and not productive. There is a tendency to be extravagant user behavior. Several campuses have taken steps to save energy, namely optimizing energy-saving devices and providing energy-saving guidelines to change user behavior [3].

Research has also been conducted to find out how far the level of knowledge, attitudes, and behavior influences energy consumption [4]. Wasteful behavior is the biggest factor that has a negative impact on energy consumption. The inefficiency of energy consumption is also caused by the cheap energy policy implemented by the Government of Indonesia [5]. In general, all users must consider that saving electrical energy must be supported by efficient behavior and equipment technology.

One of the energy-saving and sustainable technologies is the source of electrical energy from solar panels. Solar panels convert sunlight into a source of electrical energy. Solar panels can replace primary electricity sources such as PLN. However, the output of this device must be able to be monitored to see the stability of the output parameters such as Voltage, Current, Power, Power Consumed, and Time. These data can be added to the Tariff parameter in order to see how much the savings/efficiencies are in terms of costs.

For this reason, it is necessary to design a data acquisition and monitoring system for these parameters. The design of this system consists of hardware and software. The hardware design will implement a wireless sensor network (WSN), ESP32 microcontroller as an IoT component, access point, relay, and other supporting components. Software design uses C++ programming, web programming (PHP and HTML), and web display templates using Grafana. Data storage using thingspeak technology-based cloud.

Data on the used power load will be acquired and monitored with a web-based service so that it can be accessed anytime and anywhere. Data is collected on idle time and operating hours. The collected data will be analyzed to predict savings in electricity consumption when using solar panels. The results of this study are expected to be a reference in managing electrical energy efficiency at the campus.

The formulation of the problem in this research is how to acquire data and monitor Power Consumed. This system is used to see the stability of the output and the power used from the solar panel power source.

The limitations of this study are the data acquisition and Power Consumed monitoring system using IoT-based components such as the SIM7600 communication module, ADC module, ESP32 Microcontroller, and WSN. Information about the amount of Power Consumed can be accessed and displayed in real-time via the internet.

The objectives of this research are:

1. To build a Power Consumed monitoring data acquisition system as a solution for saving electricity use on the POLMED campus.
2. Building a Data Acquisition monitoring system for Utilized Power as a monitor for the output stability of solar panels.
3. Utilizing Green Technology for alternative sources of electrical energy so that the Sustainable Development Goals on electrical energy sources can continue.

II. THEORETICAL REVIEW

A. Internet of Things Concept

The internet industry is the new paradigm in global network technology, also known as the Internet of Things (IoT). Future technology is the most important focus in various industrial fields. This IoT implementation makes it easier to carry out operational systems for every part of the device/machine and devices that are connected through this network and work together [6].

The IoT concept provides broader benefits for devices that are continuously connected to the internet network, for example, electronic devices or other objects that are implanted with sensors and prepared to be actively connected widely both locally and globally [7].

B. Microcontroller ESP32

The ESP32 microcontroller is a microcontroller produced by Espressif System which is equipped with a wi-fi module on the chip so that it supports the Internet of Things (IoT) applications [8]. ESP32 microcontroller with input output pins complete with their designations.

The CPU used on the ESP32 microcontroller is a type Xtens dual-core LX6 - 160MHz. This is a differentiator from previous generations. This CPU is faster in processing instructions embedded in the chip. In addition, the ESP32 microcontroller is supported by wi-fi and Bluetooth.

In designing the control system, it will be easier and more efficient if you use the ESP32 microcontroller [9]. In addition, there are more output input pins compared to the previous generation, and are more power efficient [8].

C. SIM 7600

SIM 7600 is a module that can support LTE (Long Term Evolution) wireless communication mode. This communication module also integrates several GNSS (Global Navigation Satellite Systems) systems for high-accuracy satellite positioning, with several built-in network protocols.

SIM7600 is a solution for Multi-Band LTE-TDD/LTE-FDD/HSPA+/TD-SCDMA and Dual-Band GSM/GPRS/EDGE modules in SMT type supporting LTE CAT4 up to 150 Mbps for downlink data transfer. It has strong extension capabilities with multiple interfaces including UART, USB2.0, SPI, I2C, GPIO, etc. With common application capabilities such as TCP/UDP/FTP/FTPS/HTTP/HTTPS/SMTP/POP3 and MMS, this module also provides a great deal of flexibility and easy integration for customer applications. of SIM7600.

III. METHOD

A. Research Stages

In this study, there are 7 stages that will be carried out. These stages are:

1. The first stage is a literature study of the references that will be used in this study.
2. The second stage is designing the hardware data acquisition system and monitoring power consumption.
3. The third stage is the design of software for the ESP32 microcontroller and web programming.
4. The fourth stage is hardware manufacture. At this stage, the main components and supporting components are designed and assembled into an integrated circuit.
5. The fifth stage is software development. The data acquisition and power consumption monitoring system program is embedded in the ESP32 microcontroller chip and web programming is done on a laptop.
6. The sixth stage is the overall system testing of the data acquisition system and Utilized Power monitoring.
7. The seventh stage is the analysis of the measurement results of the power used.

B. Research Site

The location of research was carried out in the Telecommunications Laboratory and in Building C of the Medan State Polytechnic.

C. Measurement and Observation Parameters

The parameters to be measured in this study are Voltage (Volts), Current (Amperes), Power (Watts), Power Consumed (W), and Time (Minutes).

ISSN (Online) 2394-6849
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Vol 10, Issue 1, January 2023

IV. RESULTS AND DISCUSSION

A. Figures and Tables

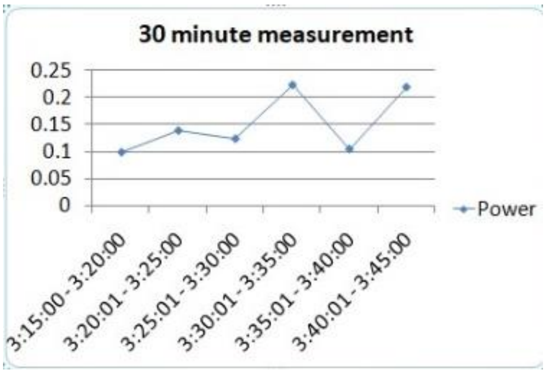

Figure 1. Results of Experiment I

Table I. Measurement Results 30 Minutes

No	Current (A)	Voltage (V)	Power (W)	Time
1	0.009	10.87	0.099	3:15:00 - 3:20:00
2	0.012	11.359	0.147	3:20:01 - 3:25:00
3	0.011	11.371	0.124	3:25:01 - 3:30:00
4	0.021	10.134	0.223	3:30:01 - 3:35:00
5	0.01	10.244	0.112	3:35:01 - 3:40:00
6	0.022	10.24	0.223	3:40:01 - 3:45:00

Table 1. Experimental Results I

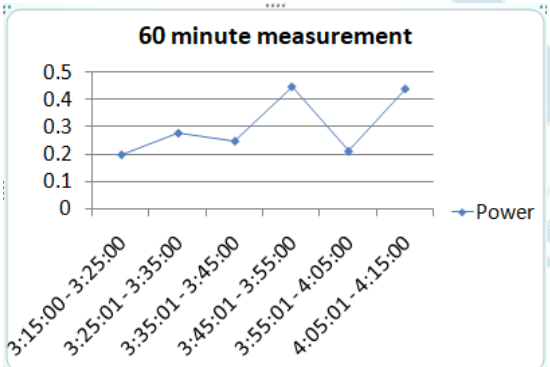

Figure 2. Results of Experiment II

Table II. Measurement Results 60 Minutes

No	Current (A)	Voltage (V)	Power (W)	Time
1	0.009	10.87	0.198	3:15:00 - 3:25:00
2	0.012	11.359	0.294	3:25:01 - 3:35:00
3	0.011	11.371	0.248	3:35:01 - 3:45:00
4	0.021	10.134	0.445	3:45:01 - 3:55:00
5	0.01	10.244	0.224	3:55:01 - 4::05:00
6	0.022	10.24	0.447	4:05:01 - 4:15:00

Table 2. Experiment II Results

In this first experiment, Di got a comparison of the length of the delay, which is from the range of 3 to 6 seconds. Figure 1 is the result of experiment I. And from the measurement for 30 minutes, the measurement data is obtained by simplifying by taking the average every 5 minutes. It can be seen in table 1. From the data table 1, it can be drawn the average value for 30 minutes of measurement, namely Strong current = 0.017 A; Mains voltage = 11.843 V; electric power = 0.16 W.

In the second experiment, Di got a comparison of the length of the delay, which is from the range of 3 to 6 seconds. Figure 2 is the result of experiment II. And from the measurement for 60 minutes, the measurement data is obtained by simplifying it by taking the average every 10 minutes. It can be seen in table 2. From the data in table 2, it can be drawn the average value for 60 minutes of measurement, namely Strong current = 0.016 A; Mains voltage = 11.843 V; electric power = 0.23 W.

This is appearance of website monitoring system of power consumption as Figure 3 below.

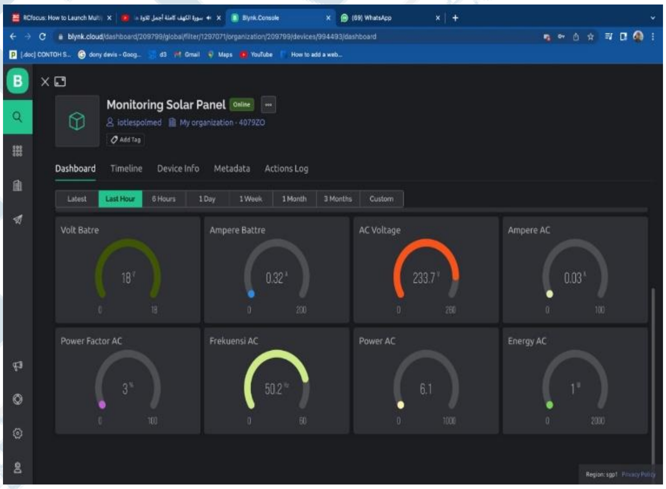

Figure 3. Website of the monitoring system of power consumption

V. CONCLUSION

Based on the research results from the Solar Panel Monitoring System, it can be concluded that; The hardware used to measure current and electric power and then send it to the database has been successfully created. Software that aims to media information on voltage, current, and electric power has been successfully made and can run smoothly. The system can work on solar panels with a voltage of 1V to 25V. When using a load the voltage decreases, and the current strength increases. And when not using a load the voltage increases, the current strength decreases. Solar panel monitoring can only be done in a place with an available internet network (WiFi). Solar panel monitoring can be done in real time using smartphones, laptops, computers and other devices that can access the internet.

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