Jurnal E-Komtek
Vol. 7, No. 2 (2023) pp. 336-346
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Application of IoT-Based Renewable Energy for Electrical Power for the Piksi Ganesha Polytechnic Campus C Laboratory

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https://doi.org/10.37339/e-komtek.v7i2.1529

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted: 17-11-2023
Revised: 07-12-2023
Accepted: 08-12-2023
Online first : 14-12-2023

Abstract

The rapid advancement of technology has increased efficiency in human activities while also escalating electricity consumption, especially with the implementing of the Industry 4.0 revolution in Indonesia. To enhance the use of renewable energy, IoT technology is employed to optimize system performance with real-time data and remote control. In the second-floor laboratory of campus c Piksi Ganesha Polytechnic, there are frequent power outages due to simultaneous use of the lab. The advantage of using this energy is that PLN electrical sources can be replaced using solar panels. This research integrates renewable energy with IoT to improve laboratory electricity usage efficiency. An ESP32-based solar panel is used to collect and control energy data. Successful testing demonstrates the ability of this system, with a 67% utilization of renewable energy. The solar cell requires attention from hardware devices. The integration of renewable energy with Telegram is efficient and can be applied to another system.
Keywords: Solar Panel, Internet Of Things, Renewable Energy

Abstrak

Kemajuan teknologi meningkatkan efisiensi dalam aktivitas manusia sekaligus meningkatkan konsumsi listrik, terutama dengan diterapkannya revolusi Industri 4.0 di Indonesia. Untuk meningkatkan penggunaan energi terbarukan, teknologi IoT digunakan untuk mengoptimalkan kinerja sistem dengan data real-time dan kendali jarak jauh. Di laboratorium lantai dua kampus c Politeknik Piksi Ganesha, sering terjadi pemadaman listrik karena penggunaan laboratorium secara bersamaan. Keuntungan dari penggunaan energi ini adalah sumber listrik PLN dapat digantikan dengan menggunakan panel surya. Penelitian ini mengintegrasikan energi terbarukan dengan IoT untuk meningkatkan efisiensi penggunaan listrik laboratorium. Panel surya berbasis ESP32 digunakan untuk mengumpulkan dan mengontrol data energi. Pengujian yang berhasil menunjukkan kemampuan sistem ini, dengan pemanfaatan energi terbarukan sebesar 67%. Sel surya membutuhkan perhatian dari perangkat keras. Integrasi energi terbarukan dengan Telegram efisien dan dapat diterapkan pada sistem lain.
Kata-kata kunci*: Panel Surya, Internet of Things, Energi Terbarukan*

1. Introduction

The increasingly rapid development of technology makes all human activities easier so that time use becomes more efficient [1]. Therefore, electricity consumption is increasing considering the rapid development and human needs. Indonesia is starting to implement the era of Industrial Revolution 4.0, which presents breakthroughs and innovations by digitalizing all sectors [2]. These activities require a substantial additional amount of electrical energy [3]. Currently, electricity is produced using non-renewable energy, namely fossil fuels such as petroleum, natural gas and coal [4]. In the long term, using fossil fuels has a negative effect because the waste produced from fossil fuel processing is unhealthy for the environment [5]. Another impact that will arise is the reduction in fossil fuel reserves [6].

Renewable energy is a solution to overcome this problem. This energy source comes from natural processes such as solar, water, air, geothermal, and biological [7]. This energy can be used continuously indefinitely because it is inexhaustible and can be renewed [8]. Of the various renewable energy sources, the energy often used comes from the sun. The sun can be a renewable energy source that can produce electricity by converting UltraViolet into electricity. Solar panels capture and convert solar heat into electricity [9]. In the long term, the application of energy with solar panels has advantages in terms of economy and efficiency of use [10].

In order to maximize the performance of the system, the Internet of Things can optimize system performance because the components are integrated with each other [11]. So, in the application, no extra work is needed when controlling and monitoring because the data produced is real-time. This research is integrated with Telegram; the Telegram bot is open source and has good security, so it is suitable for use as media for controlling and monitoring systems [12] [13].

Currently, Piksi Ganesha Polytechnic uses electrical power provided by PT PLN. On the campus of Piksi Ganesha Polytechnic, there are eight laboratories equipped with dozens of computers used as practice areas for students. There are five laboratories on the third floor, while three are on the second floor of the campus. If the entire laboratory is used simultaneously, electricity usage becomes excessive, resulting in power outages.

Based on these problems, researchers are interested in implementing alternative energy to replace the electricity source provided by PLN by using renewable energy integrated with IoT (Internet of Things). With IoT-based renewable energy, campus officers can carry out their activities anywhere because they can be controlled and monitored remotely. This application was carried out in the laboratory on the second floor of campus c at Piksi Ganesha Polytechnic.

2. Method

This research uses a design with a working system, as seen in **Figure 1**.

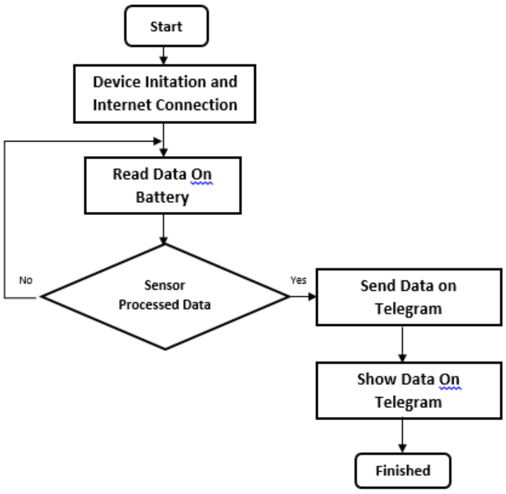

Figure 1. Flowchart System

a. Hardware Design

This implementation uses an ESP32 microcontroller, which is interconnected with various components so that the system can work automatically. This design was carried out using Fritzing. Hardware design Internet of Things is presented on **Figure 2**.

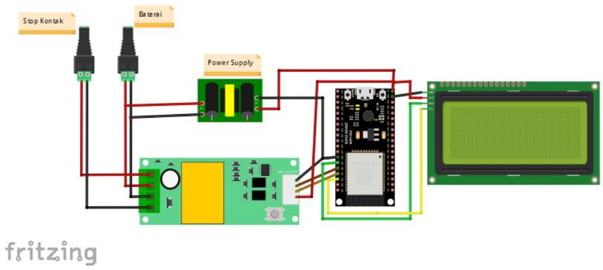

Figure 2. Hardware Design Internet of Things

Based **Figure 2**, the components used are ESP32, PZEM-004 sensor, and power supply. In the end, data will be displayed on Telegram and i2C 128x64 LCD so the electrical power can be appropriately monitored.

The circuit starts with the voltage from the battery entering the power supply and the PZEM-004 sensor. The voltage in the power supply enters the 5V input on the ESP32 as electricity to turn on the ESP32 and will keep it running, ground on the power supply connected to ground the ESP32. Then, the 5V voltage on ESP32 is distributed back to the i2C 128x64 LCD, and then the SDA pin on the i2C 128x64 LCD is connected to pin on the i2C 128x64 LCD connected to pin D21 ESP32. 5V input connected to PZEM-004 sensor, then the ground on ESP32 connected to PZEM-004 ground. After that, the RX pin on ESP32 is connected to the TX pin of the PZEM-004 sensor. Next, the TX pin on ESP32 is connected to the RX pin on the PZEM-004 sensor. Then, attach the positive cable from the electrical terminal to the positive output on the PZEM-004 sensor and the negative cable on the electrical terminal connected to the negative output on the PZEM-004 sensor. The function of each other component can be seen in Table 1.

Table 1. Function of hardware design components

No.	Component	Function
1.	Power Supply	As an energy source to power the circuit in the display box
2.	PZEM-004 Sensor	To regulate voltage, current, power, frequency, power factor
3.	ESP32	As a control center for the entire component, it can integrated with the internet
4.	i2C 128x64 LCD	For display solar panel daya
5.	Box Display	As a component container

b. Smart Energy Design

After designing the hardware component, the next step is to design the solar panels that will be implemented; the design can be seen in **Figure 3**.

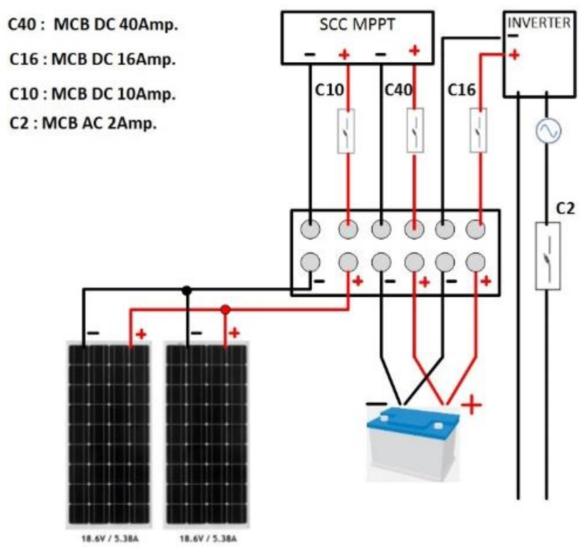

Figure 1. Wiring Smart Energy

This stage consists of two solar panels, batteries, and cables. The components that will be applied to the panel box are the Maximum Power Point Tracking Solar Charge Controller, 3 DC mcb, one inverter and 1 AC current mcb. The battery used in this installation is a VLRA battery.

Moreover, the solar panel used in this application is monocrystalline and capable of producing 120 Watts of power. Function of smart energy components is presented in **Table 2**.

Table 2. Function of Smart Energy Components

No.	Component	Function
1.	Solar Panel	To capture sunlight energy and convert it into electricity
2.	Box Panel	As a component container
3.	Baterai	As a place to store electricity produced by solar panels
4.	Power Inverter	To convert DC into AC
5.	MPPT SCC	As a battery charging controller
6.	MCB AC	As a safety measure, if the electric current experiences a surge
7.	MCB DC	As a safety measure, if the electric current experiences a surge
8.	Kabel	As an intermediary for flowing electricity

c. Software Design

At this stage, the author uses Arduino Ide software to program the ESP32 microcontroller so it can work as expected. The programming language used in Arduino Ide is C programming **[14].** The output results received by the microcontroller are real-time and can be seen on the LCD or Telegram.

3. Results and Discussion

Application of this renewable energy uses a 35-meter cable from installing solar panels on the fourth floor of campus c to the laboratory on the second floor of campus c at Piksi Ganesha Polytechnic. When the panel box was installed, four mcb were used. However, the panel box had more slots until it accommodated six mcb to be redeveloped into another room, not limited to the laboratory. Two solar panels are used so that they can produce 240 Watts. The VLRA battery used has a specification of 12V 100Ah. To determine the capacity of the battery, use the formula:

$$P = V \times I$$

$$P = 12 \times 100 = 1200$$

So, the battery used in this research is 1200 Watts-hours. This renewable energy has been used for two months; there is no problem with the system; even though it was used repeatedly. Panel box and solar panel can be seen on **Figure 4.**

(a) (b)

Figure 2. (a) Panel box (b) Solar Panel (6)

Testing is carried out by considering the data provided to the system [15]. This test was taken based on the result of intelligent energy charging for one day from 09.00-14.00 until the battery was full; charging data can be seen in Table 3.

Table 3. Electric Charging

No.	Time	Input	Information
		Voltage (V)	
1.	08.00	12.8 V	Works
2.	09.00	62.8 V	
3.	10.00	148.32 V	
4.	11.00	186.95 V	
5.	12.00	226.10 V	
6.	12.30	237.23 V	

The data in Table 3 refers to the intensity of sunlight. If less sunlight falls down the solar panel, the time required to charge the battery will be longer. Display panel can be seen on Figure 5.

Figure 3. Display on LCD 128x64

Based on the result of renewable energy charging in Table 3, tests and energy charging were carried out for 24 hours for one day. Laboratory electricity loading data is taken based on the usage per hour in Watt-hour units. Where watts are the load power, while hours are the hours used by the load being tested or how long the load is carried out. Watt-hour (Wh) calculations can use the formula:

$$E(Wh) = P(W)\ x\ T(h)$$

$$Energy = Power\ x\ Time$$

Calculation energy for all equipment can be seen on **Table 4**.

Table 4. Laboratory Electrical Loading

No.	Equipment	Usage Time	Capacity (W)	Duration (h)	Energy (Wh)	Total	Amount of Energy
1.	Lab Lights	08.00	5 Watt	3 Jam	15 Wh	10	150 Wh
2.	Arduino	08.30	5 Watt	1 Jam	5 Wh	3	15 Wh
3.	Charge Handphone	08.30	10 Watt	45 Menit	4,5 Wh	1	4,5 Wh
4.	Charge Handphone	09.00	22,5 Watt	30 Menit	11,25 Wh	1	11,5 Wh
5.	Charge Handphone	10.00	33 Watt	30 Menit	16,2 Wh	1	16,2 Wh
6.	Soldering	10.00	100 Watt	1 Jam	100 Wh	1	100 Wh
7.	Lab Lights	13.00	5 Watt	2 Jam	10 Wh	10	100 Wh
8.	Charge Handphone	13.20	10 Watt	45 Menit	4,5 Wh	1	4,5 Wh
9.	Arduino	13.45	5 Watt	1 Jam	5 Wh	4	20 Wh
10.	Soldering	13.50	100 Watt	45 Menit	45 Wh	1	45 Wh
11.	Charge Handphone	14.00	10 Watt	35 Menit	3,5 Wh	1	3,5 Wh
12.	Outdoor Lab Lights	19.00	10 Watt	12 Jam	120 Wh	5	600 Wh
13.	Lab Lights	19.00	5 Watt	3 Jam	15 Wh	10	150 Wh
14.	Arduino	19.27	5 Watt	1 Jam	5 Wh	6	30 Wh
15.	Charge Handphone	19.48	15 Watt	1 Jam	15 Wh	1	15 Wh
Total energy in the morning							296,95 Wh
Total energy during the day							173 Wh
Total energy at night							795 Wh
Total energy used							1.264,95 Wh

The data above was taken based on lecture activities in the campus laboratory c on the 2nd floor of Piksi Ganesha Polytechnic. When loading is carried out from morning to afternoon, electrical power can be used without worrying about the battery running out. This is because testing is carried out from morning to afternoon when the battery is being charged by power generated from solar panels. The battery's electric power is used from the afternoon until the evening when the sun no longer supplies sunlight to solar panels. Testing during the day is presented on **Figure 6.**

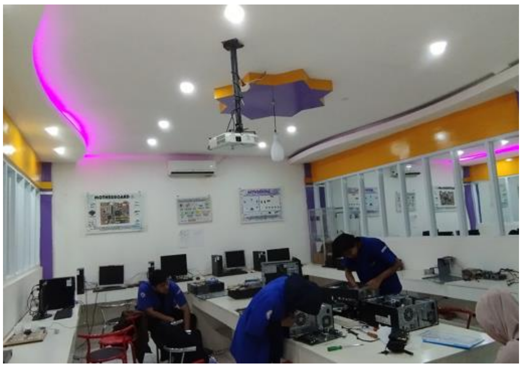

Figure 4. Testing During the Day

Based on the data in Table 4, electric power consumption at night reaches 795Wh, with a battery power consumption percentage of 67%. The capacity of the equipment used at night is 125 Watts; this data is taken by calculating on **Table 5** and testing at night can be seen on **Figure 7**.

$$Capacity\ x\ number\ of\ loads\ used$$

Table 5. Equipment Load at Night

No.	Equipment	Time	Capacity	Total	Total Capacity
1.	Outdoor Lab Lights	19.00	10 W	5	50 W
2.	Lab Lights	19.00	5 W	6	30 W
3.	Arduino	19.26	5 W	6	30 W
4.	Charge Handphone	19.48	15 W	1	15 W
Total capacity at night (W)					125 W

Figure 5. Testing at Night

During two months of operation, all components functioned well; this cannot be separated from routine maintenance. The maintenance carried out consisted of the following:

a. Clean the solar panels regularly to avoid dirt that sticks to them, which can obstruct sunlight from being absorbed by the solar panels.
b. Checking the cables used: This step anticipates no damaged cables because the cables connected to solar panels are outside the room. This checking is carried out once a month.
c. The panel box is checked to check the condition of the electronic equipment in the panel box and to anticipate animals making nets inside the box.

This is necessary so the entire system can work well and renewable energy can be used for a long time.

Renewable energy is starting to use the main components of solar panels, batteries, and MPPT SCC(Maximum Power Point Tracking Solar Charge Controller). In this research, renewable energy is applied directly and can be used on a reasonably large scale. The sun dramatically influences battery charging in solar panels [16]. The brighter sunlight will make more incredible energy, but this depends on the type and specifications of solar panels used.

Solar panels as an energy source often use Arduino Uno as a microcontroller to monitor system performance [17]. In this research, the microcontroller used in the solar panel system is ESP32, which is equipped with Bluetooth and WiFi modules.

4. Conclusion

Based on the tests, using renewable energy as a substitute for laboratory electricity resources has proven efficient. The result of the intelligent energy test carried out for 24 hours did not experience any problems because the electricity used from morning to noon did not drain the battery power. The battery used when night falls consumes 67% of the battery's capacity. This indicates that the VLRA-type battery is suitable for carrying the energy produced by solar panels. Based on the data above, the author recommends the application of renewable energy in another system.

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