ELECTRICITY MANAGEMENT SYSTEM WITH TECHNOLOGY INTERNET OF THINGS

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Abstract—*The increasing global demand for electricity has put a strain on energy resources and raised concerns about environmental sustainability. To address these challenges, the integration of modern technologies is crucial. This research presents a study on the implementation of an Electrical Energy Management System (EMS) using Internet of Things (IoT) technology. The proposed system aims to optimize electrical energy usage, enhance efficiency, and reduce the environmental impact. The EMS employs IoT devices and sensors to monitor and collect real-time data on electricity consumption in office buildings. Through data, the system can identify patterns and anomalies in energy consumption, allowing for informed decision-making and proactive energy management strategies.*

Keywords: *Electrical Energy Management System, Energy Saving, Internet of Things, IoT.*

Intisari—*Permintaan global yang semakin meningkat terhadap listrik telah menimbulkan tekanan pada sumber daya energi dan menimbulkan kekhawatiran tentang keberlanjutan lingkungan. Untuk mengatasi tantangan ini, integrasi teknologi modern menjadi hal yang sangat penting. Penelitian ini menyajikan studi tentang implementasi Sistem Manajemen Energi Listrik (SMEL) yang menggunakan teknologi Internet of Things (IoT). Sistem yang diusulkan bertujuan untuk mengoptimalkan penggunaan energi listrik, meningkatkan efisiensi, dan mengurangi dampak lingkungan. SMEL menggunakan perangkat dan sensor IoT untuk memantau dan mengumpulkan data secara real-time tentang konsumsi listrik di gedung perkantoran. Melalui analisis data, sistem ini dapat mengidentifikasi pola dan anomali dalam konsumsi energi, memungkinkan pengambilan keputusan yang berbasis informasi dan strategi manajemen energi yang proaktif.*

Kata Kunci: *Sistem Manajemen Energi Listrik, Penghematan Energi, Internet of Things, IoT.*

INTRODUCTION

Electrical energy is one of the basic needs that is very important for human life today, almost all human activities are related to electrical energy (Kastutara, 2022). Electricity as a source of energy has an important function not only as a source of lighting energy but also as a source of supporting energy in carrying out daily activities. Electrical energy sources currently have the existence of being able to support various forms of operational activities, be it lighting, communication and information facilities, education, transportation, health, household activities and many other activities (Sudarti, et al., 2022). The electrical energy management system is a system implemented to save electrical energy. In general, current electrical energy management systems are implemented manually, both for controlling and monitoring electrical devices (Rizal & Ardian, 2019).

There are many dangers caused by electric current, one of which is the danger of fire caused by an increase in temperature that exceeds limits. In electrical installations, the danger of fire can be caused by excessive loads on conductors, switches, machines, equipment, etc., if the current value is too high, excessive heat development occurs. The connection between conductors or conductors and other installation components is less than perfect, thus allowing broken contacts to occur which will trigger sparks. This poor insulation condition will

result in a short circuit current between the conductors and also a ground connection current between the current from the conductor to the ground. These currents result in a local increase in extra heat. Placement of electrical machines and equipment without calculation, such as placing electric motors in narrow, closed areas without ventilation.

Basically, the danger of electricity threatens three things or objects. First, it threatens humans, which is the most serious threat, humans can die because of electricity and that cannot be paid for by anything. The second is threatening the house or building. This second threat is no less serious and if the house or building catches fire then the losses suffered usually reach large numbers. The third is threatening other goods, especially electronic goods. This threat can be said to be the lightest threat because if the electronic goods are damaged or burned, the losses suffered will not be as serious as the losses caused by the first and second threats (Kamuihkar, et al., 2022).

A total of 17,768 fire cases occurred in Indonesia throughout 2021, with 5,274 of them caused by short circuits or around 45 percent. Meanwhile, non-fire rescue operations reached 79,559 times. This means that the incidence of non-fire rescues is almost 5 times higher than rescues due to fire. The flow of electric current through the body has different levels of consequences depending on the strength of the current, length of contact, voltage, body resistance, area of the body in contact. If you are shocked by an electric shock of 1 mA there is no serious impact, but if you are shocked by an electric current of more than 10 mA it can result in illness. and damage to the skin and even result in muscle spasms, while electric currents above 100 mA 50 Hz AC will damage body organs such as the heart and risk death. Research on animals, namely mice, shows that the maximum current that touches the mouse's body with a voltage of 220 Volts (AC) is between 110-128 mA, the mouse will die in less than an hour after being shocked by electricity for 60 seconds. The main problem is that ordinary people only know about electricity from the consequences that arise when electrical energy is used, such as lights that turn on, refrigerators that can cool food, air conditioners that can reduce room temperature.

So in conditions like this it is necessary to provide education about electrical energy with the main material presented being easy to understand, such as how electricity is generated, transmitted, distributed and utilized in everyday life. Furthermore, what is more important is education about the dangers of electricity for humans, containing material on standardizing electrical equipment, standardizing the design of electrical installations, the risks of accidents caused by electricity that must be avoided and handling victims after electric shock (Putra, et al., 2022).

Ensuring the safety of electricity consumption is crucial in preventing accidents or damage to electrical equipment that can lead to financial losses and even endanger human safety. Careless actions in electricity usage, such as using electrical appliances beyond their capacity, improper cable installation, or using damaged equipment, can result in fires or electrical short circuits. One of the fires that occurred at home was caused by an electrical short circuit. Sourced from data from the DKI Jakarta Provincial Central Statistics Agency, information was obtained that 65.82% of fires that occurred in Jakarta were caused by negligence in the use of electricity (Shaid, 2023). One of the causes of electrical short circuits is manual control of electrical devices. Thus, automation of electrical control is an effort to suppress fires caused by excessive use of electrical loads.

Energy conservation is also a critical issue considering the limited energy resources and their environmental impacts. Excessive electricity consumption without considering efficiency can lead to resource wastage. Therefore, energy-saving efforts need to be taken seriously to alleviate pressure on energy resources Automatic control of electrical power needs special attention. The application of technology to home automation must be able to guarantee the safety, security and comfort of life at home.and reduce negative environmental impacts (Azizi & Arinal, 2023).

Until now, the Internet is known as a network that connects people and information. However, the Internet has now developed far from its original concept, where not only computers and telephones can be connected, but objects or things around us can also send and receive data. The Internet of Things (IoT) is an evolution of the Internet where objects can be identified and connected to each other via the Internet. It is estimated that it will include 26 billion objects and connect 4 billion people by 2025. This development will create many opportunities and opportunities from different sides. human life. However, like the Internet and other technologies, IoT will impact users and society at large.

Internet of things or also known as IoT is an advanced technology that has a concept that aims to expand and develop the benefits of continuously connected internet connectivity. connecting objects around us so that daily activities become easier and more efficient, which really helps all human work. The importance of the internet of things can be seen by its increasing application in various areas of life today. According to the RFID (Radio Frequency

Identification) identification method, the term IoT is classified as a communication method, although IoT can also include other sensor technologies, wireless technology or QR (Quick Response) codes. The term "Internet of Things" consists of two main parts, namely Internet which connects and regulates connectivity and Things which means an object or device. Simply put, you have “Things” that can connect to each other to collect data and send it to the Internet. This data can also be accessed by other “Things” as well. where certain "Things" have the ability to send data over a network wherever you are and without any interaction from human to human or from human to computer device (Selay, et al., 2022).

Internet of Things or IoT, is a concept/idea whose aim is to expand the benefits of internet network connectivity that is fully connected and can be connected to devices, machines and other physical objects by using networks, sensors and actuators to obtain data and manage it, so that machines can collaborate and act according to new information obtained independently (Nahdi & Dhika, 2021).

The goal of IoT is to change the way we live today by making smart devices around us to perform everyday tasks. Smart home, smart city, smart transportation, smart infrastructure and others are terms used in relevance to IoT (Mantik, 2022).

By leveraging IoT, users can remotely access and control electrical appliances through applications on their mobile devices. This aids in optimizing energy usage and ensuring that electrical appliances only operate when necessary. For instance, room heaters or coolers can be scheduled or adjusted based on operational schedules or environmental conditions automatically, avoiding energy wastage when rooms are unoccupied.

Furthermore, the use of sensors and smart devices within the IoT system allows real-time monitoring of energy consumption in various areas. Data collected from these IoT devices can be analyzed to identify inefficient consumption patterns and provide recommendations for energy conservation. Users can also receive notifications or alerts in case of abnormal energy consumption or potential safety risks, such as short circuits or electrical leaks. IoT (Internet of Things) has become an increasingly widely used technological concept. Both for industrial and commercial purposes. With the presence of IoT (Internet of Things), several electronic components such as sensing facilities and control facilities such as servo motors and other devices can be controlled automatically as long as the device is connected to the Internet (Ikwan & Djaksana, 2021). Current technological developments in the field of electronics have made human thinking increasingly advanced in the application of electronic devices. One thing that has been developed is electronic technology that allows remote control of home electronic devices using Internet of Things technology. Internet of Things (IoT) technology is a concept that aims to expand the benefits of always-on Internet connectivity. IoT can combine physical and virtual objects through the use of data collection and communication capabilities (Akbar Gumilang, et al., 2022).

By integrating IoT into the electricity management system, users gain better control over energy management and avoid power wastage. Additionally, an IoT system connected to a smart grid infrastructure can serve as a bridge to incorporate renewable energy sources, such as solar and wind power, into the existing electricity grid. This contributes to enhancing overall efficiency and sustainability in electricity consumption. An Internet of Things (IoT)-based electrical energy monitoring system that is connected to a website is one of the solutions for increasing capacity, efficiency, and convenience in carrying out electrical energy audits as an effort to conserve electrical energy (Aditya, et al., 2023).

Djabesmen Alia Building whose main focus is on building management owned by PT Djabesmen, the building is named Alia Building with 8 floors located in Gambir, central Jakarta. The building manager of Alia Building is a division led by the Department Head. The main task of the building manager is serving the needs of tenants which includes technical and non-technical services.

In the Alia Building there is a canteen located in the backyard area of the building, electricity is used freely without any restrictions and is not in accordance with the rental fee, apart from that, excessive use of equipment and unsafe installations can result in potential fires due to increased load. Therefore, the use of an electrical energy management system with internet of things technology in the Alia building canteen can be a solution:

1. Monitor electricity usage in the canteen which has not been measured;
2. Limit the use of electrical equipment with excessive power which results in energy waste; and
3. Prevent the danger of fire due to short circuits in installations and equipment.

By making tools with IoT technology and using web-based applications it is possible to control electrical equipment in the canteen area. This research was conducted from April 2023 to July 2023.

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MATERIALS AND METHODS

Electricity energy management system is a web-based application that is used to control electronic equipment so that it can minimize wasteful use of electricity and prevent the danger of fires caused by electricity.

NodeMCU ESP8266 is an open source IoT-based platform. Consists of hardware in the form of System On Chip ESP8266. Currently NodeMCU has undergone 3 upgrades. The device we use is NodeMCU version 3 (V1.0) which has better capabilities than the previous version (Manullang, et al., 2021). The NodeMCU ESP8266 has integrated Wi-Fi capabilities, making it perfect for IoT projects that require a wireless connection. This allows these devices to connect to Wi-Fi networks, communicate with other devices, and send data to servers or cloud platforms. The NodeMCU ESP8266 is often used because of its ease of programming. The platform has great community support and many code examples are available for various projects.

The design of an electricity energy management system with IoT technology uses the NodeMcu ESP8226 board with the ESP 12E. NodeMcu ESP8226 is an open source IoT platform. Nodemcu is a tool used as a microcontroller to process data. This data is obtained from the PZEM 004T sensor which sends data in the form of voltage, current and power to the electronic equipment to be measured and displayed on the LCD.

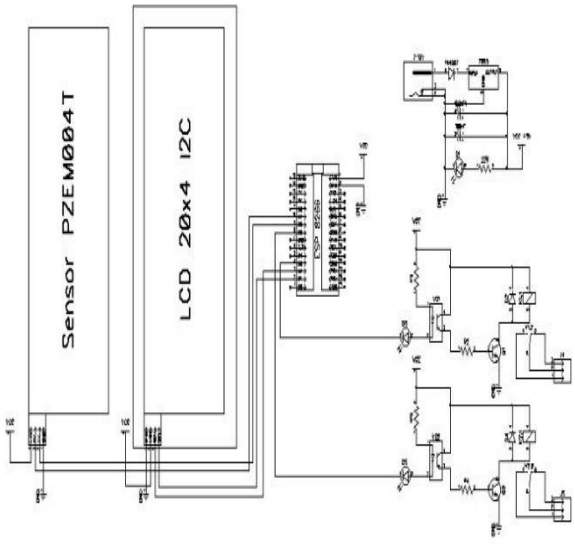

Figure 1. Sensor Circuit Schematic

ESP8266-DevKitC is a small-sized ESP8266-based development board produced by Espressif. All of the I/O pins of the module are broken out to the female pin headers on both sides of the board for easy interfacing. Developers can connect these pins to peripherals as needed.

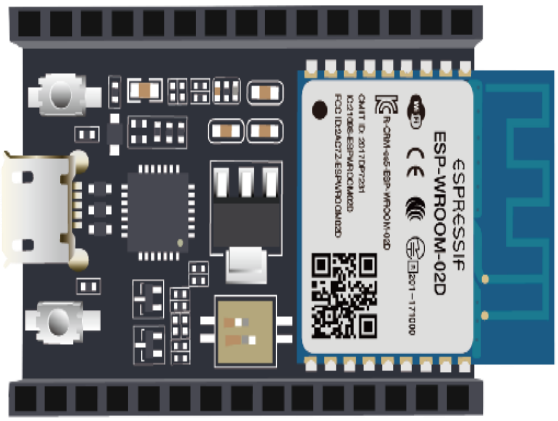

Figure 2. ESP8266-DevKitC

The PZEM-004T sensor is a sensor that can measure current, voltage, power and energy from AC power. This sensor outputs with serial communication. If we want to connect with Arduino, the communication used is serial communication.

Figure 3. PZEM-004T

PZEM-004T is a sensor that can be used to measure Root Mean Square (RMS) voltage, RMS current and active power which can be connected via Arduino or other open source platforms. The physical dimensions of the PZEM-004T board are 3.1 × 7.4 cm. The pzem-004t module is bundled with a 3mm diameter current transformer coil which can be used to measure a maximum current of 100A (Anwar, etal., 2019).

To calculate the percentage of sensor accuracy, the equation is used

$$\%\text{Akurasi} = \left(\left(1 - \frac{\text{NilaiSensor} - \text{NilaiAlatukur}}{\text{NilaiAlatukur}}\right) \times 100\%\right) \ldots (1)$$

IoT (Internet of Things) architecture refers to the structure and design of interconnected devices, networks, and systems that enable the exchange of data and information between physical objects and the digital world. It encompasses the various components, protocols, and layers that make up an IoT ecosystem.

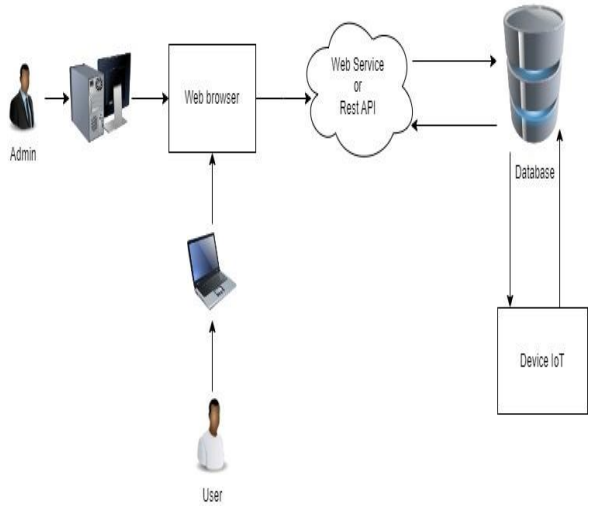

Figure 4. IoT Architecture

RESULTS AND DISCUSSION

On this occasion the author did some testing on the tool. the first is testing the accuracy of the PZEM 004T sensor against industrial standard measuring instruments, testing the tool against each individual load in the form of an electronic device, and testing control and monitoring of electricity on the SMEL WEB application (www.smel.web.id).

At this testing stage the author uses 2 measuring instruments that have industry standards as follows:

a. Digital Clamp Meter Kyoritsu type KEW 2007R and Clamp Meter MT87 Digital Clamp Meter are used to measure current (Ampere); and
b. Digital Multimeter SANWA type CD800a Digital Multimeter is used to measure Voltage (Volts).

PZEM 004T sensor accuracy test results data shown in the following table:

Table 1. Voltage Accuracy Calculation

No	Electrical Load	Voltage (Volt)		
		Multi Meter	PZEM 004T	Accuracy (%)
1	Refrigerator	224.2	224.5	99.8
2	Electric Stove 1	221.3	221.4	99.9
3	Electric Stove 2	229.1	229.2	99.9
4	Rice Cooker	221.1	221.2	99.9
5	Water Heater	230.2	230.4	99.9
6	Showcase	231.4	231.7	99.8

The table 1 shows the average accuracy level of the PZEM 004T sensor compared to a multimeter for measuring voltage on several electronic devices is 99.98%.

Table 2. Current Accuracy Calculation

No	Electrical Load	Current (Ampere)		
		Pliers Ampere	PZEM 004T	Accuracy (%)
1	Refrigerator	0.70	0.74	94.3
2	Electric Stove 1	11.1	11.3	98.2
3	Electric Stove 2	7.5	7.7	97.3
4	Rice Cooker	1.3	1.39	93
5	Water Heater	4.4	4.43	99.3
6	Showcase	1.4	1.53	90.7

The table 2 shows the average accuracy level of the PZEM 004T sensor compared to the ampere pliers for measuring current in several electronic devices is 95.4%.

Table 3. Power Accuracy Calculation

No	Electrical Load	POWER (Watt)
		PZEM 004T
1	Refrigerator	165
2	Electric Stove 1	2.439
3	Electric Stove 2	1.769
4	Rice Cooker	307.6
5	Water Heater	1.017
6	Showcase	266

From the testing process, it can be concluded that the sensor voltage gets an average measurement accuracy = 99.98% and for current the average measurement accuracy = 95.4%.

Figure 4. IoT Architecture

The following picture is an electrical energy management system that has been installed in the Alia building canteen.

Table 4. Power Accuracy Calculation

No	Loads	Voltage (V)	Current (A)	Power (Watt)	Energy (kWh)
1	Refrigerator	224.5	0.74	165	0.66
2	Electric Stove 1	221.40	11.03	2439.60	9.75
3	Electric Stove 2	229.1	7.7	1769	7.07
4	Rice Cooker	221.2	1.39	307.6	1.23
5	Water Heater	230.4	4.3	1017	4.06
6	Showcase	231.7	1.4	266	1.06

This testing process to find out how good and consistent this tool is in monitoring the use of electrical energy. For testing the tool with a load it is carried out for 4 hours per tool, monitored in real time via the web application or directly via the LCD.

CONCLUSION

At the end of this research, the Electrical Energy Management System implemented in the Alia Building Canteen has made a significant contribution to more efficient and controlled electrical energy management. With the existence of an Electric Energy Management System, the use of electrical energy in the canteen can be monitored directly via a web application or via cell phone. If the canteen is not operating, the building manager can turn it off using this system so as to minimize the danger caused by electricity.

The ability to control electrical energy via the website in real time has opened the door for Alia Building Managers to monitor and manage electrical energy more effectively. Although this research also reveals several shortcomings that need to be considered in further development.

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