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Energy efficiency on public street lighting using LTE lamp based IoT control

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ABSTRACT

Nowadays, The Medan city has developed public street lighting along the protocol highways. The government has spent billions bugdet to readiness. The estimated electrical consumption for public street lighting will be 47.06 MW by 2025. Therefore, energy efficiency is required to complete the system of public street lighting. This research use LTE lamp to control electrical consumption for lamps. There are 4 main components, namely LTE Lamp Controller, which is including a LoRa component, light sensors BH1750, SIM card, and fuzzy logic program. Cloud server as a storage for measurement data. Monitoring devices as laptop or smartphone. GSM network as interface networking between LTE lamp controller and cloud server. The sunlight intensity affected to the dimming value of the lamp. It uses fuzzy logic to regulates the switching of lamps. LTE lamp controller supports the dimming mode such as 0-10V dimmer. This voltage directly correlates to the light output. At 10 Volt, the lamp should produce 100% light. At 0 Volt, 0% lighting output or off. Based on the result, The highest of sunlight intensity is 7796 lux generating the voltage of 1 Volt (lamp off). The lowest of sunlight intensity is 1028 lux generating the voltage of 7 Volt (lamp on).

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1. INTRODUCTION

Nowadays, The Medan city has developed a public street lighting project along the protocol road. The government has spent a total of IDR 25.7 billion to repair the public street lighting and sidewalks. Efficiency of public street lighting are very important (Ali et al., 2024)(Boulmrharj et al., 2023). They need a large proportion of the electrical energy (Huang et al., 2019)(Verma et al., 2023). According to the research, the predicted of electrical energy consumption in the Medan city will be 3,476.90 GWh by 2030. This represents an increase of 5.99% per year. The estimated electricity consumption for public street lighting will be 47.06 MW by 2025.

Lots of steps towards energy efficiency in public street lighting systems. It conducted, such as public street lighting uses intelligent street lighting technologies for transport operation. The paper discusses a modern concept of smart street lighting that for illuminating city streets implies the use of special street lamps controlled via intelligent platforms. These platforms can regulate the intensity of lighting according to environmental conditions. The weakness of the research, special street lamps are very expensive (Voskresenskaya et al., 2020).

An automatic saving system for public street lighting use microcontroller. This system is equipped with photocell sensor, PIR sensor, LDR Sensos, and LED Lights. The weakness of the research, the system can not connect to internet yet (Fachrudin et al., 2021). Energy-efficient measures for existing fully air-conditioned buildings have been carried out in this research. The result is 40% of electrical consumed in commercial buildings in Hong Kong succesfully achieved, but this is not for public street lighting (Gupta, 2019).

Saving electrical energy on public street lighting will change human perception. People will feel more comfortable and safe if public street lighting is adequate. Therefore, energy efficiency of electrical consumption for public street lighting is still progressing (Vetter et al., 2022)(Rahm & Johansson, 2021)(Durmus et al., 2022).

Today, energy conservation is a practice of reducing the energy used. The existing old installation generally consume more energy than the new installation because of their unavoidable stagnations in physical performances (Ray et al., 2023)(Ustinov & Khomiakov, 2022)(Owusu-Manu et al., 2022). This technology is depending on their features and customization requirements. The technology has led to the development of intelligent lighting. These devices will Human and vehicle movement detection, time settings, step dimming, enabling dynamic lighting and dimmer control (Lutfi Hadi Azizul Adry et al., 2023)(Yusuf et al., 2021)(Kang et al., 2020). The technology also allows one device to communicate with another, for example, If a pedestrian or car is detected, the street lights is switch on. Sensors and cameras will be added to the device (Hassan et al., 2024)(Villa et al., 2021)(Zhao et al., 2022).

In addition, the benefits of public street lighting will increase in terms of saving and efficient use of electrical energy. It will increase of satisfaction for road users both pedestrians and bikers. The system is integrated. But, this is without its drawbacks, which is a high initial investment in transform the conventional system as an intelligent one (D'Angiolini et al., 2021)(Fuchtenhans et al., 2019)(Herningtyas & Yulianti, 2023).

For this reason, the study of public street lighting control is needed. The development of the Internet of Things technology at this point in time is expected to have an impact on the control of remote and integrated systems (Hossain et al., 2022)(Eriyadi et al., 2021)(Chiradeja & Yoomak, 2023). Control and monitoring system connected via the Internet. The parameters under control are on/off switching, lighting levels, and all these parameters can be under control using web-based applications.

2. RESEARCH METHOD

The research design is presented in the form of a schematic as shown in Figure 1. There are 4 main components, namely: (a) LTE Lamp Controller, which is including a LoRa component, light sensors BH1750, SIM card, and fuzzy logic program. (b) Cloud server as a storage for measurement data. (c) Monitoring devices as laptop or smartphone. The application used is Fonda City Platform. The appearance is shown as Figure, (d) GSM network as interface networking between LTE lamp controller and cloud server.

Schematic design is shown as Figure 2. A LoRa component, light sensors BH1750, SIM card, and fuzzy logic program are placed in LTE Lamp Controller chasing. This device will read the data from the sensors. The parameters are the sunlight intensity value captured by the sensor and the voltage value at the LTE cell output pin.

Fluctuations of sunlight intensity will have an impact on the automatic on/off system of the lamps. There is fuzzy logic in the mechanism of determining the lamps on/off system.

Data measurements were carried out during the day starting from 11:00 a.m. - 2:30 p.m. at the POLMED campus. Measurements were made during 5 working days, but the results and analysis chapter will show measurement data for 1 day only. Technical specification of LTE lamp device is consist of LTE GSM mode, 7-pin interface plug and play, TCP protocol supports remote connection to the server, remotely turn on/off, dimming interface, failure detection: lamp failure, power failure, over-voltage, over current, under voltage, power outrage, automatically report failure notification to the server, built-in RTC support scheduled tasks, and built-in photocell to auto control via Lux value.

Figure 1. The appearance of platform

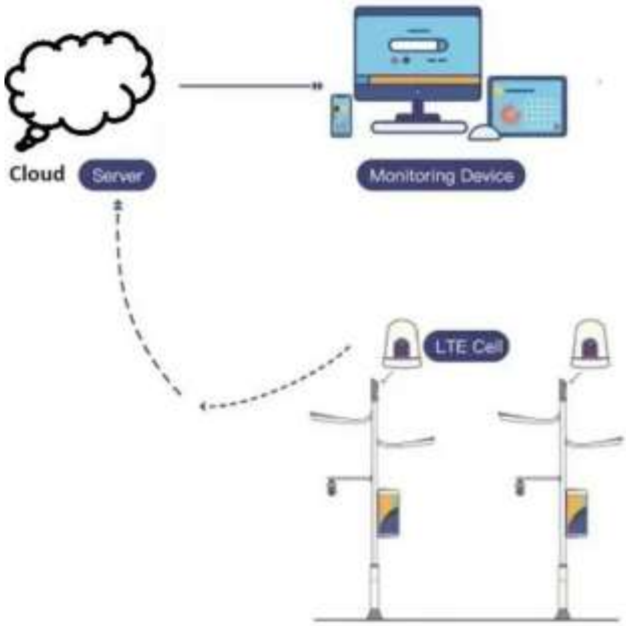

Figure 2. Schematic design

This system is designed for remote and integrated control of public street lighting. The parameter to be measured is lighting intensity around the public street lamp and the voltage. All measurement data is stored centrally on the server. The data transmission network is the GSM network. This network has coverage in almost all regions of Indonesia, so information or data is about vehicle objects, weather conditions and people.

All are accessible online. The information is available in real-time. By controlling public street lighting, We are able to ensure savings and efficiency in the use of electrical energy. It can raise the satisfaction of all road users, both pedestrians and cyclists.

3. RESULTS AND DISCUSSIONS

LTE lamp controller has been implemented as shown in Figure 3 and Figure 4. Data collection was carried out at 11:00 a.m - 2:30 p.m at the POLMED campus. Data collection was carried out in the playground and sidewalks. This is done to make it easier for authors to get the natural light intensity. The following is the data obtained in Table 1.

Based on the results of the experiment, sunlight intensity affected to the dimming value of the lamp. This LTE lamp device supports two types of dimming modes, such as 0-10V and DALI (Digital Addressable Lighting Interface). A 0-10V dimmer is a simple electronic signaling system originally used to dim fluorescent lighting fixtures. It sends the signal one way, controller to driver in DC voltage varying between 0 and 10 Volt. This voltage directly correlates to the light output. At 10 Volt, the lamp should produce 100% light. At 0 Volt, 0% lighting output or off. The graphic of sunlight intensity versus 0-10V dimmer is shown as Figure 4.

DALI is a protocol to communicate with drivers in both directions. It would allow a device to exchange real-time and stored data over a two-wire bus. The return data can be information such as historical power consumption, confirmation and successful execution of a command, run-time, fixture identification and fixture failure.

LTE lamp controller uses fuzzy logic control that regulates switching of public street lighting. There is a lux sensor of BH1750 inside the device chassis. This sensor reads the light intensity from outdoors, and then the data is processed by the fuzzy controller to determine which lights should be turned on to achieve optimal lighting intensity.

The system is also equipped with monitoring and control features that can be accessed via the internet. Through this application, users can monitor the amount of lux read by the sensor. The auto switching turns on/off according to predetermined fuzzy rules. This feature makes it easy for users to control and monitor the system in real-time via internet.

Figure 3. LTE lamp controller devices

Figure 4. LTE lamp controller implementation

Table 1. Test Results

Hours (WIB)	Sunlight Intensity (lux)	Lamp Status
11.10	5029	off
11.15	5895	off
11.20	5935	off
11.25	5715	off
11.30	5391	off
11.35	4715	off
11.40	3013	off
11.45	4983	off
11.50	3073	off
11.55	2648	on
12.00	1532	on
12.05	1028	on
12.10	2209	on
12.15	2887	on
12.20	6234	off
12.25	6555	off
12.30	7796	off
12.35	5263	off
12.40	3309	off
12.45	4157	off
12.50	6412	off
12.55	7717	off
13.00	7013	off
13.05	7267	off
1310	6978	off
13.15	6751	off
13.20	3760	off
13.25	5185	off

13.30	2278	on
13.35	1191	on
13.40	1649	on
13.45	3823	off
13.50	3505	off
14.00	2917	on
14.05	1938	on
14.10	2143	on
14.15	2153	on
14.20	3121	off
14.25	2303	on
14.30	2160	on

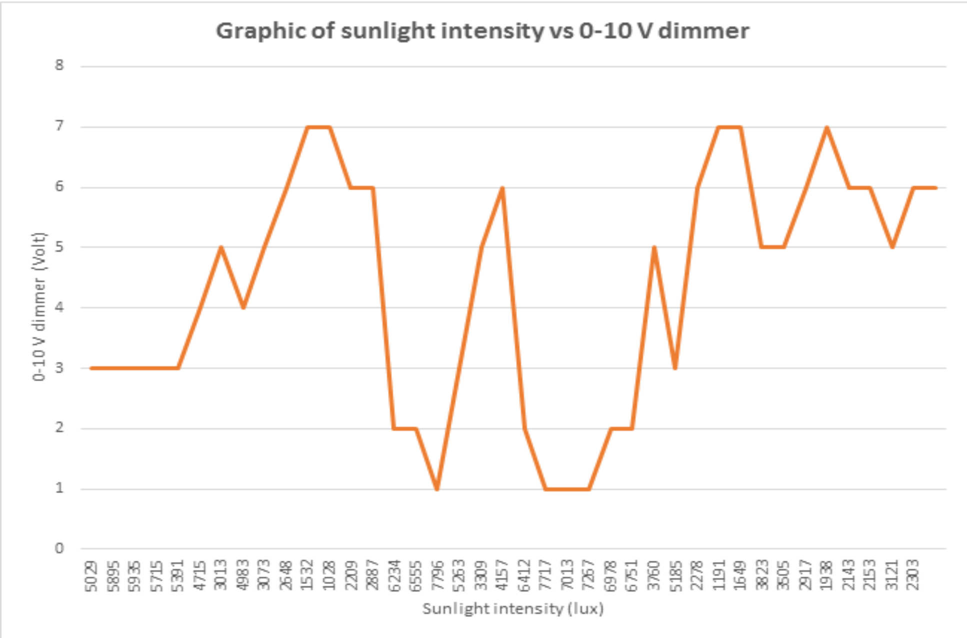

Figure 5. Graphic of sunlight intensity versus 0-10V dimmer

4. CONCLUSION

LTE lamp controller is able to control the consumption of electrical energy in public street lighting. The dimming system can reduce the electric power load for the lamps. Fuzzy logic plays an important role in controlling the dimness level based on the light sensor readings. Fuzzy logic using 0-10V dimmer facility provided by the LTE lamp controller. This research produces a inverse correlation between the value of sunlight intensity and the output voltage of the LTE lamp controller. The lamp will turn on if the sunlight intensity value is low. Based on the research results, the value of the sunlight intensity range of 1000-3000 lux will produce a voltage of 6-7 Volts. This value is able to turn on the lights in a bright state. This research was only conducted on 1 LTE lamp. Further research will be developed on the coordination of more than 1 LTE lamp. The more LTE lamp controller is used, absolutely more electrical energy will be saved. The preservation of nature is maintained and the sustainability of human life because the existing energy can be utilized effectively and efficiently.

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