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An Estimation of Electrical Energy Saving for Lecture Building at Universitas Andalas Using Daily Electric Need Pattern

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Abstract. Electrical energy is a mandatory requirement for carrying out various kinds of human activities. Nowadays, electrical energy must be used efficiently, that is, as needed. However, in use, it is often done excessively and inefficiently, which causes energy loss. It has an impact on the high spent on electricity costs. This research was conducted using an analytical method to obtain a pattern of ideal daily energy consumption needs for various kinds of academic activities in the Universitas Andalas lecture building, namely during the lecture period, exam period, and lecture holidays. The ideal pattern of needs is obtained by considering electrical equipment data, lecture schedules, the questionnaire results on electricity users' behavior, and the value of lighting intensity. The pattern is plotted on a graph every 30 minutes for 24 hours. The pattern results are then compared with current electrical energy usage to evaluate everyday electrical energy use to improve future use. Based on testing the pattern of ideal electrical energy needs with current, it is found that electrical energy is the least efficient during the lecture holidays with a percentage value of 55% to 75%.

1. Introduction

Nowadays, electrical energy is a mandatory requirement for every human activity, both in the industrial sector, households, to buildings. The building sector currently plays an essential role as the highest energy consumer and the main contributor to greenhouse gas emissions. The building sector (residential, commercial, office) represents about 40% of total world energy consumption and offers significant potential for cost-effective energy savings. Therefore, it is mandatory to understand the factors contributing most to energy consumption in a building [1].

The use of electrical energy in buildings is closely related to user behavior in the building itself. The proper use of electrical energy is used based on their respective needs. The needs are different for each building, often causing energy-losses. Theeffective and efficientelectrical energy used can be determined by knowing in advance the proper electrical energy needs. It is necessary to look at the electricity needs used effectively and efficiently in each building.

Energy management is a policy aboutusing energy to obtain maximum benefits (minimum costs) and enhance a competitive position [2]. In general, things that must be considered in preparing an

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energy management program are to consider several aspects, namely: the behavior of energy users, the equipment technology used, installation, or installation of equipment and equipment maintenance management. The energy management system of ENMs is a process of continuous improvement by the PDCA loop (Plan Do Check Act cycle)[3]. Since this topic is related to evaluate the use of electrical energy in existing buildings, it focuses more on the Check and Act section.

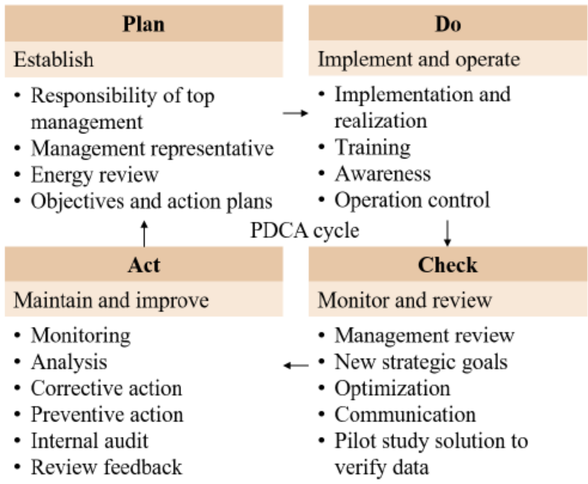

Figure1. PDCA cycle in the energy management system[3]

Energy conservation is an effort to make energy use more efficient for a need to avoid energy loss. Energy conservation is the efficient and rational use of energy without reducing essential energy use. Energy management is an effort to regulate and manage energy use as efficiently as possible in buildings without reducing the comfort level in the residential environment and productivity in the work environment [4]. Awareness and concern for the use of energy and the indoor environment of all people using the building are very important. Education and training can improve building occupants' understanding of building management efforts to maintain and increase the building's energy efficiency and contribution. Zero Energy Building (ZEB) is defined as a building used as a residential or commercial facility that can reduce energy needs drastically so that efficiency is achieved. In this state, a balance of energy needs supplied with renewable energy is achieved. The steps to attain Zero Energy Building are as follows [5]:

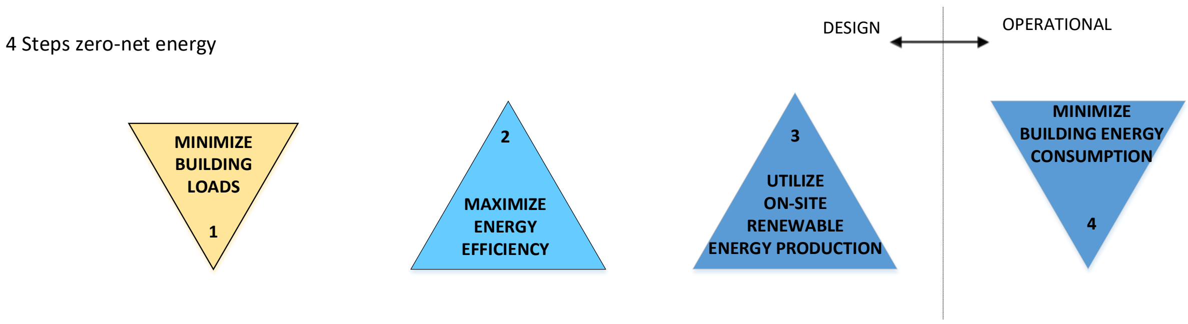

Figure2. Chart of Design and Implementation of Zero Energy Building (ZEB)*[5]*

Where :

1. Minimize Building Loads (Minimizing Building Loads)
2. Maximize Energy Efficiency (Maximizing Energy Efficiency)
3. Utilize On-Site Renewable Energy Production (Utilizing the Production of Renewable Energy On-Site)

4. Minimize Building Energy Consumption (Minimizes Building Energy Consumption.

Universitas Andalas is one of the building sectors in the education sector that consumes electrical energy. As mentioned in the announcement in the entire building at Universitas Andalas by Vice-Chancellor, electricity costs reach 720 million per month. Six hundred million must be paid to fulfill electricity needs only for campus activity and 120 million for electricity payments for the campus teaching hospital[1]. The preliminary research had been conducted to address this issue[4,6,7]. However, the need for electrical energy in the buildings on Universitas Andalas campus varies according to its use and function. One of them is the lecture building, which is always used for the teaching and learning process by Universitas Andalas academic community. Teaching and learning activities have been arranged in the campus academics' schedule, which also regulates campus activities each month, such as any month for regular lectures or exams, be it midterm exams or final semester exams to class holiday schedules. Preliminary research had been conducted to address this problem.

2. Materials an methods

This research is calculates each class's power and energy in the lecture building, defined in figure 3.

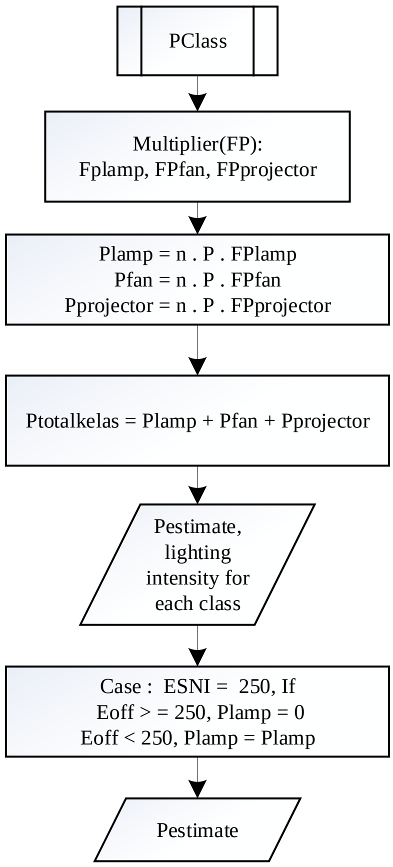

Figure3. The flowchart in calculating electric needed for each classroom

In getting current energy usage, we develop a dashboard for the energy information system. It is based on a client-server architecture and web-based application that collect data from each measurement point. Each measurement point is recorded energy data for each building, including the lecture building. The data is transferred using TCP/IP protocol into the server to visualize as an energy dashboard. The system's architecture can be seen in figure4, and figure 5 shows a dashboard of the energy information system.

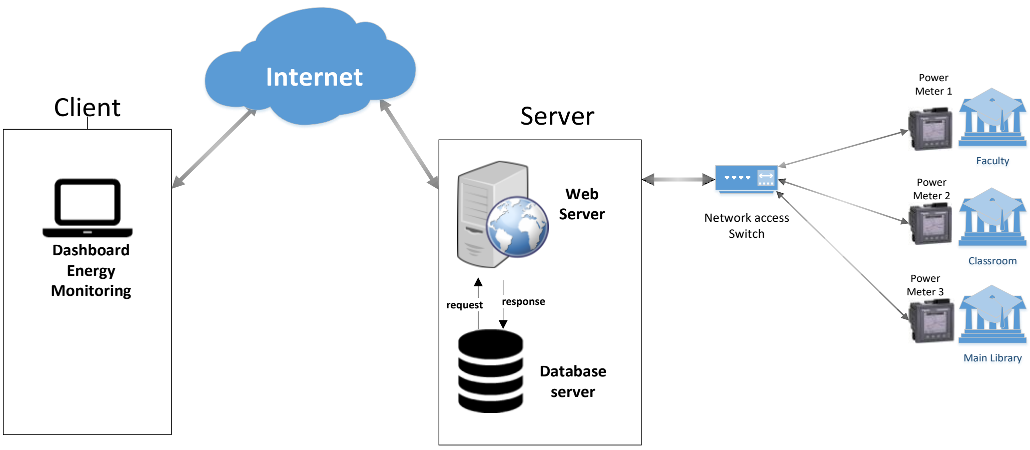

Figure 4. Energy information system architecture

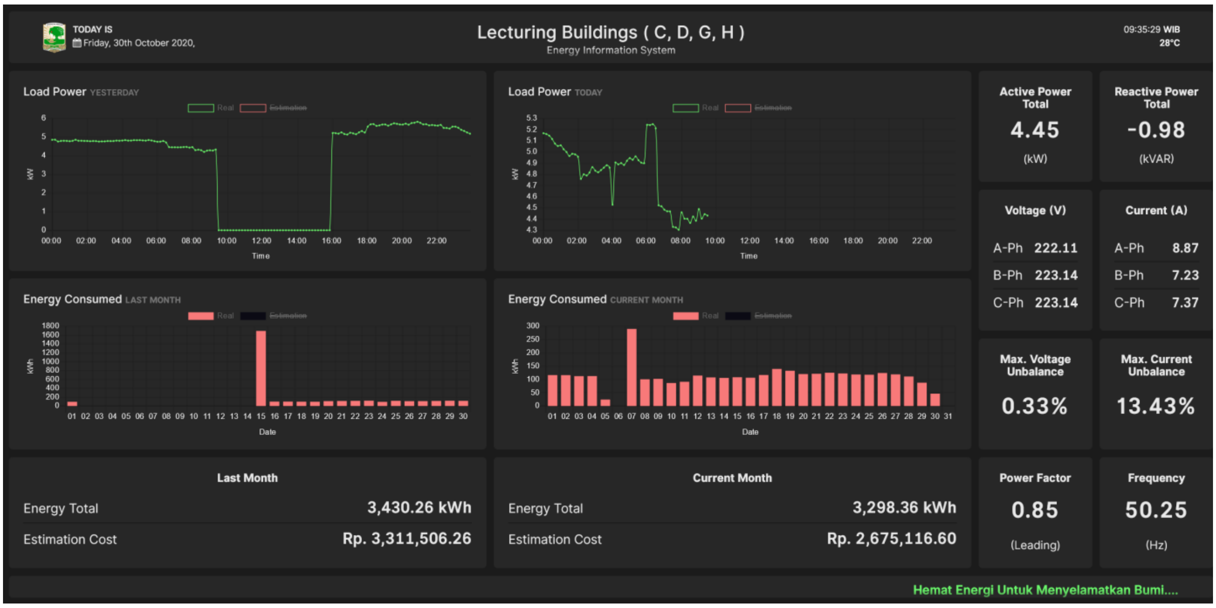

Figure 5. The dashboard of Energy Information System

3. Results and discussion

An estimation data was carried out every 30 minutes for 24 hours for one week. Energy consumption patterns are grouped into three based on the lecture schedule period in the lecture building, namely during the lecture period, the exam period, and the lecture holiday period. The pattern of electrical energy consumption in the three periods varies for each day in all lectures. The pattern of electrical energy needs per day in a week between each lecture activity period is also different.

In modeling the ideal pattern of electrical energy consumption needs in the C, D, G, and H lecture buildings of Universitas Andalasis obtained by calculating and processing data by entering data in the form of existing electrical equipment data, class schedules, multiplier factor (FP) values and intensity values lighting. Based on these data, the pattern of electricity consumption needs can be seen in figure 6-11:

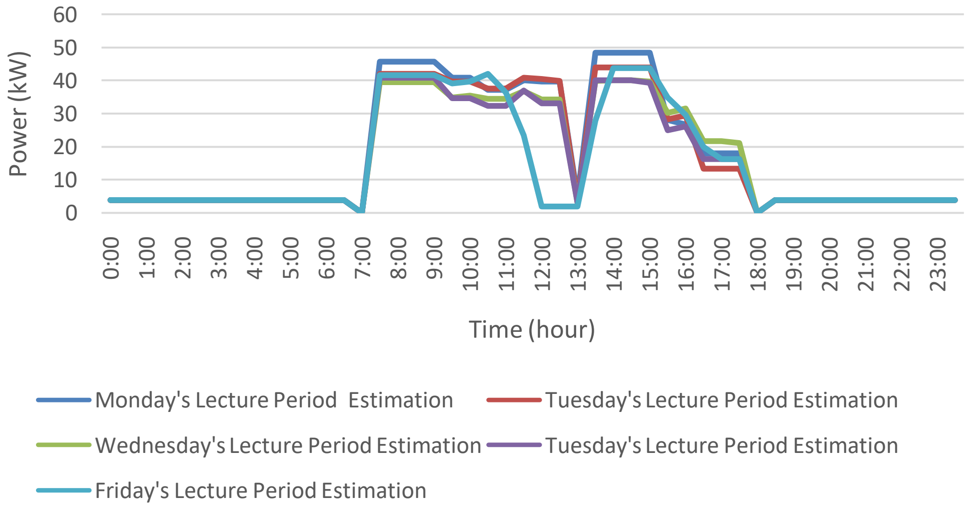

Figure6. Estimation ofpower usage on a workday during the lecture period

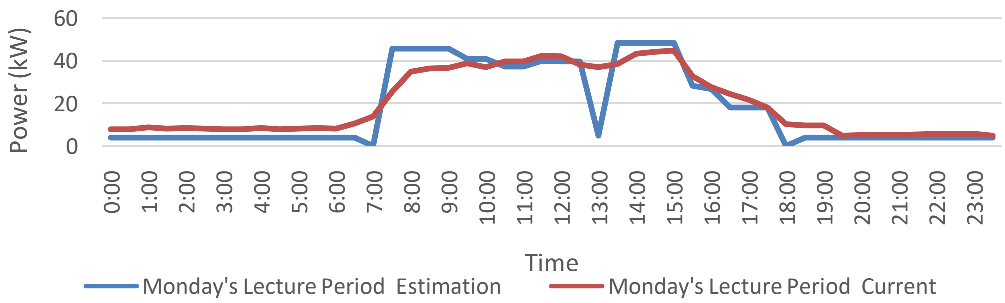

Figure7. Comparing an estimation and current usage on Monday during the lecture period

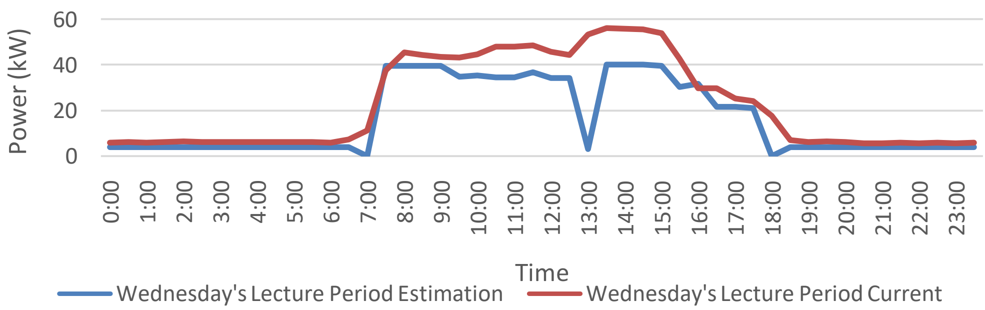

Figure 8. Comparing an estimation and current usage on Wednesday during the lecture period

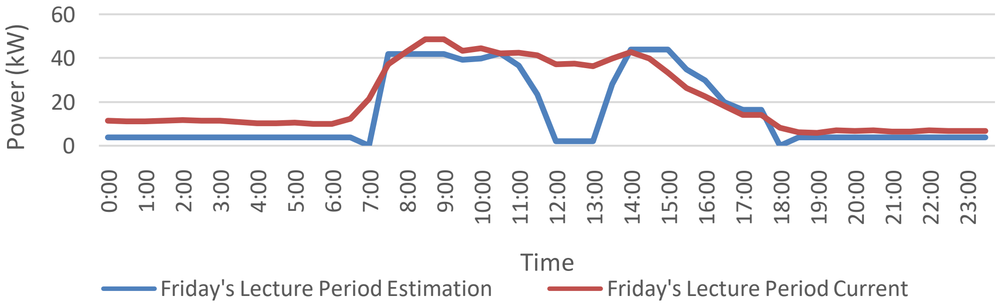

Figure 9. Comparing an estimation and current usage on Friday during the lecture period

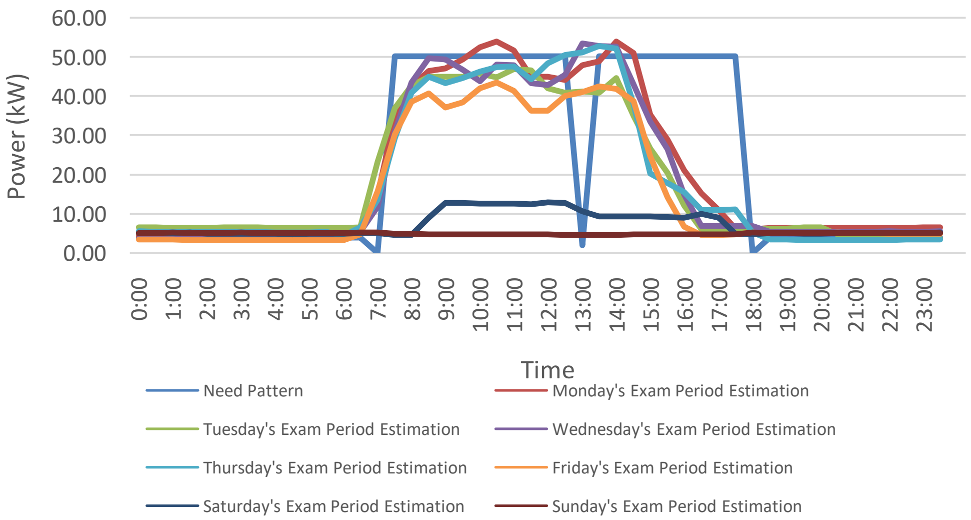

Figure 10. Estimation power usage on a workday during the exam period

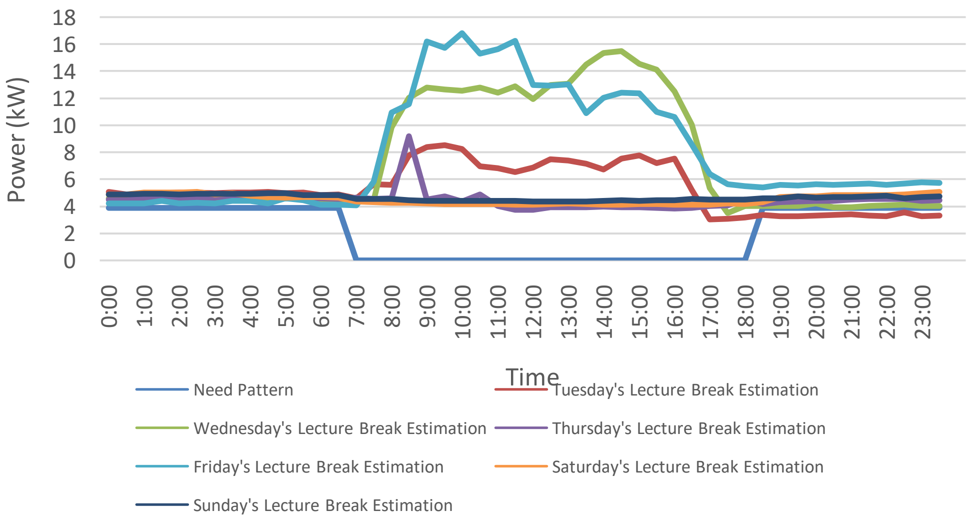

Figure 11. Estimation power usage on a workday during the lecture break

Based on figure 7-12, it can be seen that the pattern of electricity consumption needs is different for each day. However, from the graph, it can be seen that for current use, as shown in the real-time graph, the everyday use of electricity consumption is still used outside of necessity. For example, the most obvious thing is for the lecture holidays, in which during the day, there should be no use of electrical energy. However, in real-time conditions, it can be seen that there is still electrical energy, even having a value of more than 15 kW likewise on other days. During the lecture period, outside needs can be seen at the afternoon break, which should have decreased the power value, but the decrease in power that occurs is minimal from the previous power value.

The proper use of electrical energy is to use electrical energy effectively and efficiently. The practical and efficient use of electricity is meant to use electrical energy as needed. With the previously obtained power need patterns and real-time measuring power, it can be seen whether the current use of electrical energy has been effectively used by using the following equations:

$$W = P_{tot} \cdot t \tag{1}$$

With equation 1, each type of day's energy value is obtained in the need pattern and real-time measurement.

$$Percentage\ of\ loss\ (\%) = \frac{E_{\ pola} - E_{realtime}}{E_{realtime}} \times 100\% \tag{2}$$

By using equation 2, the percentage value is obtained to determine the percentage of loss by looking for differences in energy needs and energy patterns in real-time measurements. The following is the energy and rate of loss requirement patterns and real-time measurements for each type of day.

Based on table 1, it can be seen that the energy difference in need patterns and real-time measurements. Almost all day in the current usage measurement of energy value is more significant than the energy in the need pattern, except during the test period for the type of workday. It is also clarified by the positive percentage value, which indicates that the real-time energy value is greater than the energy need pattern. Meanwhile, the negative percentage indicates that the real-time energy value is smaller than the energy need pattern value.

Overall, the largest percentage value of electrical energy between need patterns and real-time measurements is during the lecture holidays and weekends (Saturday and Sunday) for all activities, with percentage values ranging from 55% to 75%. Meanwhile, on other days the percentage value feels below 30%.

Table 1. Daily energy usage dan rate in comparing estimation based on the design of energy used pattern and existing condition.

Season	Day	Estimation usage based on need pattern	Current usage	Percentage of loss (%)
Lecture Period	Monday	432.76	477.76	9.4%
	Tuesday	408.202	422.335	3.3%
	Wednesday	393.961	551.025	28.5%
	Thursday	380.663	454.86	16.3%
	Friday	363.901	507.42	28.3%
	Saturday	48.3375	178.615	72.9%
	Sunday	48.3375	187.655	74.2%
	Total	2076.162	2779.67	33.3%
Exam Period	Monday	551.789	495.425	-11.4%

	Tuesday	551.789	448.385	-23.1%
	Wednesday	551.789	463.26	-19.1%
	Thursday	551.789	451.875	-22.1%
	Friday	551.789	387.98	-42.2%
	Saturday	48.3375	172.245	71.9%
	Sunday	48.3375	119.155	59.4%
	Total	2855.62	2538.325	1.9%
Lecture break	Monday	48.3375	157.685	69.3%
	Tuesday	48.3375	127.68	62.1%
	Wednesday	48.3375	181.435	73.4%
	Thursday	48.3375	107.12	54.9%
	Friday	48.3375	192.29	74.9%
	Saturday	48.3375	108.78	55.6%
	Sunday	48.3375	111.015	56.5%
	Total	338.3625	986.005	63.8%

4. Conclusion

Based on the test and analyzes that have been carried out, it can be drawn that the pattern of daily electricity consumption needs is influenced by electrical equipment, lecture schedules, user behavior, and the value of lighting intensity in the lecture building. As long as outside working hours, the real-time power value is greater than the required pattern power value, and it can be caused by negligence in energy management. It also found that the pattern of electrical energy consumption needs on lecture days is different for each working day, where the real-time power value is greater than the pattern power requirement.In the need pattern for electrical energy consumption during the exam period, the real-time power value is close to the required pattern power during the morning before noon. During the daytime, the relative power value is relatively low compared to the power need pattern. It also can be concluded that in the pattern of energy usageduringlecture break and holidays, it has a power value that is quite large compared to the value of the power need pattern, due to illegal or unregistered activities and negligence in energy management. The use of electrical energy is currently quite efficient during working hours. However, there is still energy-loss outside working hours and during class holidays.The most significant loss of electrical energy occurs during the lecture holidays and Saturday, Sundays, based on the test results. It found that savings opportunities can be made, especially outside working hours and during lecture holidays.

Acknowledgments

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