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Implementation of lighting systems in academic building to achieve green campus

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Abstract

Lighting is a very importance aspect of any building. Energy consumption form lighting use is among the largest, accounting for approximately 5-15% of a building's total energy consumption. The academic building at P University have the highest number of users and a greater variety of room types compared to other buildings. To achieve green campus, it is necessary to measure the level of implementation and identify improvement strategies for academic building. The method used in this study is an assessment of the level implementation of the lighting system based in green building performance criteria in the Regulation of Minister Public Works and Housing (Permen PUPR) No. 21 of 2021 as well as measurements of indoor illuminance based on SNI 03-6197-2020. The results show that the academic building does not yet meet the lighting system requirements stipulated in Permen PUPR No. 21 of 2021. The lighting systems in academic buildings relies on artificial lighting and already uses LED light. Based on illuminance calculations, classroom lighting level exceed the requirements of SNI 03-6197-2020 when all lamps are turned on. Improvement strategies that can implemented to enhance performance include calculating the existing energy consumption of the lighting system and installing sensor in accordance with the standard requirements. Once the standard requirements are fulfilled, further innovations can be carried out by integrating the lighting system with advanced and up-to-date technologies.

Keywords

Lighting systems, Academic building, Light intensity, Lighting assessment, Green building

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Introduction

A university is a population consisting of students, lecturers, academic and administrative staff, researchers, and other who works or study on campus. The greater the number of activities carried out on campus, the higher the amount of energy consumed. Higher energy consumption also leads to higher costs required for its management. Activities in higher education institutions include teaching and learning activities, research, and other service-related activities. Therefore, higher education institution must manage their energy effectively in order to minimize costs and reduce

environmental impacts [1]. Based on research conducted by Islam et al., the energy related emissions generated during 2022 academic year amounted 1.900,71-ton CO_2. CO_2 emissions per capita reached 0,041 ton [2].

Efforts by higher education institution to create environmentally friendly infrastructure are promoted through the green campus concept. One of these efforts is the implementation of green buildings, with the main indicators being reduction of CO2 emissions, energy consumption, and water use [3]. The largest energy consumption in buildings generally comes from heating, cooling, lighting, and hot water usage [4].

Lighting is a very importance aspect of any building [5]. Energy consumption form lighting use is among the largest, accounting for approximately 5-15% of a building's total energy consumption [6]. Therefore, lighting systems can be considered a significant potential for reducing energy consumption in order to achieve sustainability [7]. The performance of lighting systems is related to green building has been regulated in standards and regulations. One of these is the Permen PUPR No.21 of 2021 on the Assessment of Green Building Performance.

P University is one of the higher education institutions located in South Jakarta, Indonesia. In carrying out its daily operational activities, P University has begun to implement improvements to realize a green campus. The object of this study is one of the academic buildings with the highest number of users. This building accommodates 12 study programs, 118 lectures, 77 educational staff, and 1,500 students. The academic building includes administrative offices, a hall, a library, classrooms, laboratories, and drawing studios. With the large number of activities and occupants in this building, lighting is absolutely essential. Therefore, this study analyzes the lighting system in the lecture building.

Based on the background of problems, this study aims to evaluate the lighting system of the academic building at P University based on Permen PUPR no.21 of 2021. It also involves observing indoor illuminance levels in various rooms within the lecture building with reference to SNI 03-6197-2020, and analyzing improvement strategies for the lighting system that can be implemented in the academic building.

Method

The object of this study is one of the academic buildings at P University. The academic building has four floors and consists of 16 classrooms, a library, a hall, a multimedia room, 10 administrative offices, 6 drawing studios, and 30 laboratory rooms.

This research was conducted using both quantitative and qualitative approaches. The quantitative method was used to assess the implementation of the lighting system in the academic building at P University based on the assessment aspects stipulated in the Permen PUPR No.21 of 2021 for existing building (Table 1), as well as to measure indoor illuminance levels using a lux meter and compare them with the reference standard SNI 03-6197-2020 (Table 2).

Table 1. Lighting system measurement for existing building

Indicators	Point
Natural Light	
Areas that receive natural lighting according to standards have separate groups of lights from areas that do not receive light	3
Areas receiving natural lighting according to standards, equipped with light intensity (lux) sensors that can adjust the lighting of lamps accordingly	1
Artificial Light	
The artificial lighting system of the room is planned to have a maximum power and lighting level in accordance with SNI	1
There is one switch in a room smaller than 30 m^2	1
The use of occupancy sensors/lighting controllers in rooms with specific functions as required	1

Table 2. Lighting intensity [8]

Room Function	Light Intensity (Lux)
Educational Institution	
Class Room	250
Library	300
Laboratory	500
Drawing Room	750

Meanwhile, qualitative approach was used to address the research objective related to improvements strategies for the lighting system that can be implemented in academic building at Pancasila University. This was carried out through a literature review to identify strategies applicable to academic building.

Results and discussion

The first objective of this study is to assess the lighting system of academic building at P University based on Permen PUPR No.21 og 2021. Data collection was conducted in June 2023 through interviews with the building management, and has been adjusted to reflect the current conditions. The following present the results of the assessment of the implementation of the lighting system in academic building. Assessment lighting system in academic building show in Table 3.

Based on the assessment of lighting system according to green building performance criteria for existing buildings under the Permen PUPR No.21 of 2021, the academic building has used LED light in all rooms. Efforts have been made to reduce energy consumption. However, the use of LED light is not on sufficient to significantly reduce energy consumption. According to the assessment aspects, lighting requirements in each room must be carefully calculated to ensure efficient energy use and to avoid energy waste. The use of lighting sensor systems also needs to be implemented in all rooms, rather than only partially. Since there is no energy consumption recording for the building, the efficiency of using LED light and partial sensor system cannot be determined. Light intensity measurement in laboratory and classroom show in Figure 1.

Table 3. Assessment lighting system in academic building

Indicators	Reference Points	Implemented Point	Analysis
Natural Light			
Areas that receive natural lighting according to standards have separate groups of lights from areas that do not receive light	3	2	The use of natural lighting in the lobby area, staircases. Application of separated lighting groups, has been implemented only partially and not throughout the entire building.
Areas receiving natural lighting according to standards, equipped with light intensity (lux) sensors that can adjust the lighting of lamps accordingly	1	0	Not yet implemented
Artificial Light			
The artificial lighting system of the room is planned to have a maximum power and lighting level in accordance with SNI 6197:2020 or the latest edition	1	0	There has been no calculation carried out. However, all lighting fixtures have been replaced with LED light.
There is one switch in a room smaller than 30 m^2	1	0	A room (16 m^2) may have 2-3 light switches.
The use of occupancy sensors/lighting controllers in rooms with specific functions as required	1	1	Sensory light has been installed, but only in certain locations.

Figure 1. Light intensity measurement in laboratory and classroom

To determine whether the lighting system in academic building at P University meets the require standard, the next stage involved measuring the light intensity in various rooms within the building, including classrooms, library, laboratory, and drawing rooms.

The measurements were conducted on May 31, 2023, during daytime hours using a lux meter. The light intensity measurements were carried out under 2 conditions: with all light turned off (natural lighting only) and with all lights turned on in the rooms. The following presents the average results of the light intensity measurements in the room academic building. Existing condition lighting intensityshow in Table 4.

Table 4. Existing condition lighting intensity

Room Function	Light Intensity (*Lux*)	Existing Condition Average Light Intensity (*Lux*)	
		Light on	Light off
Class Room	250	310-320	50
Library	300	288	90
Laboratory	500	320	60
Drawing Room	750	400	50

Based on the results of the light intensity measurements, when all lights are turned off, the illuminance levels area very low and not adequate for activities, making the use of artificial lighting necessary. The measurements also indicate that the classrooms have illuminance levels exceeding the required standards. With a total of 16 classrooms and operational hours form 08.00-18.00, lighting consumption is therefore relatively high. Efficiency measures that have been implemented include not turning on all lights when the numbers of student is below than classrooms capacity, and turning off all lights when classrooms are not in use.

In the laboratories and drawing rooms, the light intensity needs to be increased to ensure comfortable use. However, since these rooms are used only at certain times, the lights can be turned on only when activities are taking place. In this way, energy efficiency can be achieved.

Strategies to improve lighting efficiency require careful planning, including implementation and financial considerations. The use of LED light alone is not sufficient to achieve feasible efficiency [9]. A comprehensive calculation of the existing energy consumption of the lighting system in academic building is necessary, one of which can be carried out through simulation using DIALux. This simulation includes considering existing room conditions, such as the duration of natural daylight availability and the type of ceiling used [10]. The used of LED lighting combined with occupancy sensors can improve energy efficiency up to 60%, and reduce 62.4 ton of CO_2 emissions per year [11]. The use of such sensors is in accordance with the green building performance assessment criteria stipulated in Permen PUPR No.21 of 2021, and therefore can be implemented throughout the academic building at P University.

The lighting system in a building plays a significant role as a contributor energy consumption and CO_2 emissions. The use of LED lighting in buildings is one of the efforts to reduce energy use. LED (Light Emitting Diode) lighting are known for their high energy efficiency. The advantages of these light include a long-life service, high luminosity, and directional lighting. Therefore, LEDs are widely used to improve lighting

quality and energy efficiency [10]. The use of LED lighting has also been implemented in academic building in Malaysia. Replacing fluorescent lighting with LED has reduced energy consumption by 50% and resulted in savings of 50% the total electricity bill [12].

The use of technology in lighting systems can be applied to reduce energy consumption and operational costs. Occupancy sensors, daylight dimming technologies, and room scheduling systems yield the most significant feasible energy saving when calibrated to the genuine illuminance requirements [13], [14]. Campus-scale wireless sensor networks characterized by centralized management facilitate the streamlined deployment across extensive properties while enabling remote optimization and maintenance capabilities [12]. The sustained success of energy reduction in lighting systems can be achieved through the implementation of a long-term monitoring systems [7].

Conclusion

Based on the analysis conducted, it can be concluded that the lighting system in academic building at P University does not yet meet the green building requirements stipulated in the Permen PUPR No.21 of 2021. According to calculation of illuminance levels, lighting intensity in classrooms needs to be reduced, while in laboratories and drawing rooms it needs to be increased, in accordance with the room requirements specified in SNI SNI 03-6197-2020. Both the reduction and increase of lighting intensity will have an impact on energy consumption and operational costs. Therefore, the main target for the academic building at P University is to comply with the illuminance requirements based on SNI 03-6197-2020 and the lighting system requirements in Permen PUPR No.21 of 2021. Once all requirements are fulfilled, further innovation can be carried out by integrating the lighting system with advanced technologies.

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