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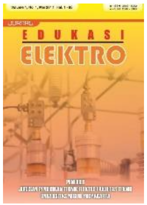

Power Consumption Analysis and Evaluation of Energy Saving Potential of Lighting System in DEF Building

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Abstract—This study aims to analyze power consumption and evaluate the potential energy savings of the lighting system in the DEF Building, which has various room functions including offices, laboratories, meeting rooms, and libraries. The study was conducted with a descriptive quantitative approach based on field measurement data. Data collection includes measuring lighting intensity (lux), inventory of types and number of lamps, and power consumption (watt). The measurement results were compared with the Indonesian National Standard SNI 6197:2020 to assess the minimum lighting level and maximum power limit. In addition, a simulation of replacing conventional lamps with LED lamps was carried out using Dialux Evo software. The results showed that most rooms had power consumption per square meter that was still efficient (<12 W/m²), but many rooms did not meet the minimum lighting standards. The simulation of replacing lamps with LEDs resulted in significant power savings, with a total reduction in energy consumption of 928.93 kWh per month or equivalent to electricity cost savings of around Rp1,362,997.48. Replacing lamps was also able to improve the quality of lighting in rooms that previously did not meet the standards. This study shows that effective lighting system management through LED lamp retrofitting can be an important strategy in supporting building energy efficiency.

Keywords: building lighting, energy efficiency, energy saving, power consumption,

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1 Introduction

Lighting systems are a vital component in building utilities because they directly affect comfort, productivity, and energy efficiency. Good lighting not only ensures adequate visibility for occupants, but also supports security, interior aesthetics, and building operational efficiency. In the context of modern buildings, lighting systems must be designed with energy efficiency, automatic control, and integration with smart building systems in mind [1]. The selection of lamp types, placement of light points, and use of sensors or timers can optimize energy consumption while creating a healthy and productive environment. The lighting system is an important part of the building utility system[2]. Lighting plays a role in the visual comfort felt by users and has a direct impact on overall energy consumption [3]. Inefficient lighting in buildings can contribute a significant percentage to the use of electrical loads, especially if the lighting system design is not based on electrical energy efficiency [4] [5] [6]. In addition, a good lighting system must pay attention to the optimal layout of the lights, as well as using the appropriate type of lights. So, it is important to manage an efficient lighting system as an effort to support energy conservation in the building sector [7] [8] [9].

Indonesian National Standard with code SNI 6197:2020 [10] on energy conservation in minimum lighting systems (lux) and maximum electrical power limits (W/m²) permitted for each room function. However, currently, there are still several buildings that ignore these provisions. Several buildings, such as office spaces, laboratories, meeting rooms, or other special rooms, often have two contradictory conditions [11]. The first condition in the room is that the power usage is low, but the light intensity level (lux) is inadequate. The second condition is that the light intensity (lux) is sufficient, but the energy usage is high and wasteful due to the selection of inefficient lamp types. The problem that usually occurs in the field is that the use of lamps still uses conventional types such as Tube Lamp (TL) or Compact Fluorescent Lamps (CFL), which have disadvantages in the form of low efficiency and service life. Currently, there are already many energy-saving lamps that also have a longer service life. One of them is the Light Emitting Diode (LED) lamp, which has advantages in terms of energy efficiency and long service life [12] [13]. Therefore, it is necessary to conduct an evaluation related to the use of types of lamps that still use conventional types so that they can be replaced by LED lamps.

This research focuses on a case study in the DEF Building, which has various room functions, including office areas, laboratories, evaluation rooms, meeting rooms, and libraries. The study aims to examine power consumption in the lighting system by considering the type and number of lamps installed. In addition, an assessment of the actual lighting level is also carried out by referring to the SNI 6197:2020 standard, as well as the preparation of a simulation of replacing conventional lamps with an LED lighting system. Through this evaluation, it is expected to obtain a concrete picture of the potential energy efficiency that can be realized is expected, as well as being a reference for retrofit planning or development of lighting systems in similar buildings.

Through a quantitative approach based on measurement data and comparative analysis between conditions before and after lamp replacement, this study provides a real contribution to efforts to support energy efficiency policies at the national level. Its focus is on the government-owned building sector and research institutions, which generally have long operating hours and a large number of workspaces. This approach is not only intended to reduce energy consumption [14], but also to improve the quality of lighting that supports the visual comfort of space users, which ultimately has the potential to boost work productivity.

2 Methods

2.1 Research Approach

Analysis of power consumption and evaluation of potential energy savings in building lighting systems, in this study using a descriptive quantitative approach based on empirical data in the field. The descriptive quantitative approach is applied to obtain an objective, factual, and measurable picture of existing lighting conditions [15]. This study was conducted by combining light intensity measurement data (lux), identification of the type and number of lamps, and analyzing the energy consumption of the lighting system used [16] [17] [18].

The data collection process was carried out directly at the research location, namely the DEF Building, which has various spaces such as office space, laboratory, meeting room, library, and service room, through lux measurement using digital measuring instruments and lamp specification observation. Furthermore, the data was analyzed by referring to the provisions of SNI 6197: which is the standard for minimum lighting levels in various room functions. To evaluate the potential efficiency, a simulation of replacing conventional lamps with energy-saving LED lamps was carried out using Dialux Evo software, so that a decrease in power consumption and an increase in lighting quality can be projected. Through this quantitative approach, the results of the study are expected to provide accurate information, not only in the context of lighting and energy consumption techniques, but also as a basis for planning efficient and comfortable lighting system retrofits for building users [19] [20].

2.2 Measurement of Lighting Intensity

Lighting intensity measurements were carried out in various rooms in the DEF Building. Measurements were carried out using a digital lux meter, with the room midpoint method, and natural lighting was minimized so that the results obtained accurately reflect artificial lighting [21]. This measurement is intended to evaluate the suitability of the actual lighting level in each room with the standards set out in SNI 6197:2020. This standard regulates the minimum lighting level based on the room function, as shown in Table 1.

Table 1. Minimum lighting level standard according to SNI 6197:2020

No.	Room	Illuminance (Lux)
1	Office room	350
2	Head office room	350
3	Meeting room	300
4	Prayer room	200
5	Living room	150
6	Warehouse	100
7	Lobby	350
8	Laboratory	500
9	Library	300

2.3 Measuring Electric Power Consumption

Measurement of the electricity consumption of the lighting system is carried out to determine the amount of energy used by each room in existing conditions. The data collected includes the type of lamp, the number of light points, the power per lamp, and the area of the room. From these data, the total power consumption (watt) and the ratio of power consumption per square meter (W/m²) are calculated, as an indicator of energy efficiency in each room. Following SNI 6197:2020, the maximum lighting power consumption allowed for office and laboratory buildings ranges from 12–13 W/m², depending on the function of the room. This value is used as a reference in evaluating whether the lighting system in a room is wasteful or energy efficient, as shown in Table 2.

Table 2. Maximum electrical power for lighting according to SNI 6197:2020

Room Function		Maximum Lighting Power (W/m2) Including Ballast Losses
Office	Receptionist	13
	Director's room	13
	Workspace	12
	Computer room	12
	Meeting room	12
	Drawing room	20
	Archive warehouse	6
	Active archive space	12
	Emergency stairwell	4
	Parking area	4

2.4 Layout and Lighting

Lighting layout is an important aspect in a building lighting system because it directly affects light distribution, energy efficiency, and visual comfort for users of the space [22] [23]. In this study, the layout and lighting arrangement of each room in the DEF Building were analyzed based on visual documentation and Dialux Evo software simulation. Each room was analyzed based on the shape of the room, the position of the lights, and the distribution of lighting. Layout visualization and lighting simulation showed that some rooms had uneven light distribution, caused by the placement of lights that were too angular, an insufficient number of lights, or visual obstacles such as cabinets and stacks of files.

An example of the results of the analysis using Dialux software related to the shape of the room, number of lights, and light distribution in the DEF Building can be seen in Figure 1 and Figure 2. By using Dialux software, the layout and arrangement of lighting in a room can be simulated well.

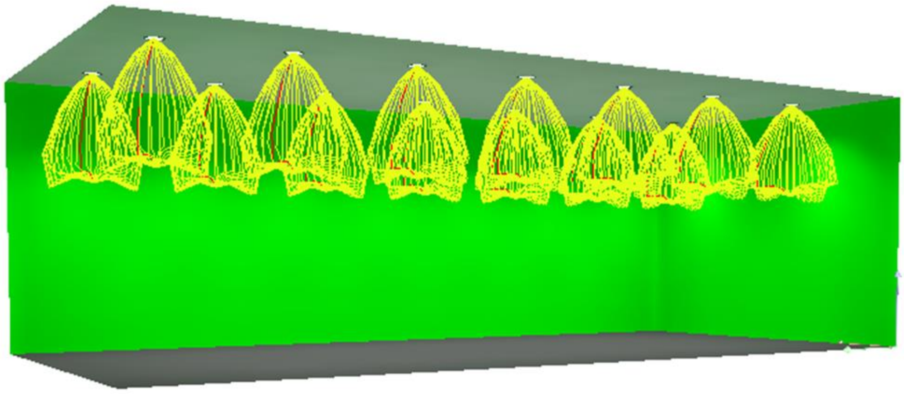

Figure 1. Room shape and lighting layout in the Kuljar research room.

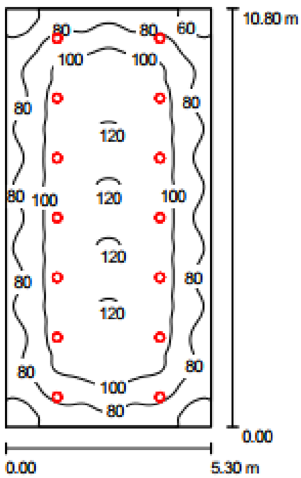

Figure 2. Distribution of Light in the Kuljar Research Room

2.5 Energy Savings Estimation

Energy-saving estimation is done based on the simulation of replacing conventional lamps with energy-saving LED lamps in several rooms that experience a mismatch in lighting levels and power consumption. This analysis includes a comparison of total power (watt), power consumption per unit area (W/m²), and estimation of reduction in electricity consumption (kWh) and savings in monthly operational costs.

Calculation Method
The estimation is done using the following formula:

$$\text{Energy Saved (kWh):} = \frac{(Power\ Before - Power\ After)\ x\ Operating\ hours\ per\ day\ x\ Number\ of\ Days}{1000} \quad (1)$$

Assuming:
Lighting hours: 8 hours per day
Working days per month: 20 days
Electricity rate: IDR 1,467/kWh (according to the average non-subsidized electricity rate in 2024)

3 Results and Discussion

3.1 Light Intensity Measurement Results

Measurement of lighting levels concerning minimum standard data according to SNI 6197:2020 in Table 1. The analysis was carried out by identifying the lighting level in each room. Rooms with lighting values below the standard are stated in the insufficient category, while rooms with lighting values reaching or exceeding the standard are stated in the fulfilling category. Measurement of lighting intensity was carried out in 25 rooms in the DEF Building using a lux meter. The measurement results were then compared with the lighting standards of SNI 6197:2020. It was found that several rooms, such as the Meeting Room, TU Room, and Server Room, have lighting levels that do not meet the minimum standards, even though their power consumption is relatively low. The results of measuring the lighting level in the DEF Building can be seen in Table 3.

Table 3. Lighting level of DEF building.

No.	Room Name	Room area (m2)	Illuminance (Lux)		Description/status
			Standard	*Measurement*	
1	Kuljar Researcher Room	57.24	300	219.45	Not suitable
2	Culture Room 2	36.12	300	559.475	According to standards
3	Meeting Room	28.62	300	94.525	Not suitable
4	Planting Room	32.68	300	475.075	According to standards
5	Preparation Room	60.52	300	588.44	According to standards
6	Seed Lab	99.54	500	567.44	According to standards
7	Pest Lab 1	23.56	500	704.675	According to standards
8	Pest Lab 2	23.56	500	852.75	According to standards
9	Finance Sub-Division Room 1	49.14	300	258.26	Not suitable
10	Finance Sub-Division Room 2	47.12	300	467.95	According to standards
11	Evaluation Service Division	94.80	300	348.7	According to standards
12	Evaluation Program Room	96.00	300	289.65	Not suitable
13	Administration Room	96.00	300	274.94	Not suitable
14	Head's Room	38.44	350	565.375	According to standards
15	Meeting Room 1st Floor	34.16	300	197.55	Not suitable
16	White Wood Lab	22.80	500	189.6	Not suitable
17	Server Room	23.94	300	169.05	Not suitable
18	Wood Lab	29.76	500	684.75	According to standards
19	Forest Biotechnology Room	39.69	300	191.55	According to standards
20	Forest Biotechnology Lab Room	97.96	500	482.1	Not suitable
21	Researcher Room	139.80	300	487.125	According to standards
22	Breeding Room 1	94.80	300	558.4167	According to standards
23	Breeding Room 2	94.80	300	165.7833	Not suitable
24	Breeding Room 3	96.00	300	187.5333	Not suitable
25	Library	96.00	300	353.3833	According to standards

Table 3 presents a summary of lighting levels (measured in lux) across 25 rooms within a research and laboratory facility, comparing actual illumination measurements against the standard requirements for each space. The findings indicate that several rooms, such as the Researcher Room (219.45 lux), Meeting Room (94.525 lux), Finance Subdivision 1 (258.26 lux), Evaluation Program Room (289.65 lux), and Server Room (169.05 lux), have lighting levels below the recommended standards, suggesting inadequate illumination. On the other hand, most laboratories, including Pest Laboratory 1 and 2, and the Seed Lab, exceeded the required 500 lux threshold, ensuring sufficient lighting for technical tasks. Overall, while most of the rooms meet or exceed the recommended lighting standards, approximately one-third still fall below the expected levels, indicating the need for lighting improvement in several critical workspaces to support visual comfort, productivity, and safety.

3.2 Results of Electric Power Consumption Analysis

The power consumption analysis of the lighting system shows that most rooms use 36W TL lamps or 18W SLDL lamps, with the amount varying depending on the size of the room. The ratio of power consumption to room area (W/m²) is an early indicator of the efficiency of the lighting system. The results of the analysis of electrical power consumption can be seen in Table 4.

Table 4. The ratio of power consumption to the area of space (W/m²)

No.	Room Name	Room area (m^2)	Specifications and Analysis				
			Types of Lights	***Quan-tity***	***Total Power (W)***	***W/m²***	***Description/ status***
1	Kuljar Researcher Room	57.24	SLDL: 18W	14	350.0	6.11	efficient
2	Culture Room 2	36.12	TLRM: 36W TL: 40W	6 4	420.0	11.63	efficient
3	Meeting Room	28.62	SLDL:15W	8	200.0	6.99	efficient
4	Planting Room	32.68	TLRM: 36W	6	252.0	7.71	efficient
5	Preparation Room	60.52	TLRM: 36W	6	252.0	4.16	efficient
6	Seed Lab	99.54	TLRM: 36W	8	336.0	3.38	efficient
7	Pest Lab 1	23.56	TLRM: 36W	2	84.0	3.57	efficient
8	Pest Lab 2	23.56	TLRM: 36W	4	168.0	7.13	efficient
9	Finance Sub-Division Room 1	49.14	TLRM: 36W	12	504.0	10.26	efficient
10	Finance Sub-Division Room 2	47.12	TLRM: 36W	12	504.0	10.70	efficient
11	Evaluation Service Di-vision	94.80	TLRM: 36W	24	1008.0	10.36	efficient
12	Evaluation Program Room	96.00	TLRM: 36W	21	882.0	9.19	efficient
13	Administration Room	96.00	SLDL: 36W	3	141.0	1.47	efficient
14	Head's Room	38.44	TLRM: 36W	9	378.0	9.83	efficient
15	Meeting Room 1st Floor	34.16	TLRM: 36W	4	168.0	4.92	efficient
16	White Wood Lab	22.80	SLDL: 15W	7	175.0	7.68	efficient
17	Server Room	23.94	TLRM: 36W	7	294.0	12.28	not efficient
18	Wood Lab	29.76	TLRM: 36W	8	336.0	11.29	efficient
19	Forest Biotechnology Room	39.69	TLRM: 36W	9	378.0	9.52	efficient
20	Forest Biotechnology Lab Room	97.96	TLRM: 36W	24	1008.0	10.29	efficient
21	Researcher Room	139.80	SLDL: 18W TLRM: 20W	17 9	641.0	4.59	efficient
22	Breeding Room 1	94.80	TLRM: 36W	24	1008.0	10.63	efficient
23	Breeding Room 2	94.80	TLRM: 36W	18	756.0	7.97	efficient
24	Breeding Room 3	96.00	TLRM: 36W	24	1008.0	10.50	efficient
25	Library	96.00	TLRM: 36W	24	1008.0	10.50	efficient

Based on the data in Table 4, the electricity consumption of the lighting system in most rooms in the DEF Building is relatively efficient. Almost all rooms show a power consumption value per square meter (W/m²) that is below the maximum threshold set by SNI 6197:2020, which is around 12 W/m² for workspaces and laboratories. Some rooms even show very efficient figures, such as the Administration Room which only consumes 1.47 W/m², the Seed Lab at 3.38 W/m², and the Kuljar Research Room at 6.11 W/m². This shows that in general the lighting system in the building has implemented the principle of energy efficiency. However, one room was found to have a power consumption value that exceeded the limit, namely the Server Room with a power consumption of

12.28 W/m². This value slightly exceeds the standard limit and needs special attention because it can contribute to energy waste, especially if the room operates for a long duration every day. Judging from the type of lamp used, most rooms still use conventional 36W TL lamps or 15–18W SLDL spiral lamps. Although this type of lamp is still commonly used, in terms of lighting efficiency, these lamps have lower lumens per Watt (lumen/W) compared to LED lamps. As a result, although the power consumption is relatively small, many rooms do not have lighting that reaches the expected brightness level. This condition is supported by previous light intensity (lux) measurement data, which shows that several rooms such as the Meeting Room, Administration Room, and Server Room have lighting levels below the minimum standard. Based on this, it can be concluded that an energy-efficient lighting system does not necessarily produce good lighting in terms of visual quality. Therefore, strategies that can be carried out include replacing the type of lamp with LED, adding the number of lamps in certain rooms, and rearranging the position of the lamps to achieve even light distribution. This effort is not only aimed at saving energy but also ensuring comfortable and standard lighting throughout the building.

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3.3 Simulation of Replacement to LED System

Replacement of lamps to 20W LEDs was carried out in priority rooms, such as the Server Room, Forest Biotechnology Lab, 1st Floor Meeting Room, and Breeding Room. The simulation results showed a significant decrease in power consumption without sacrificing lighting. Several replacements and additions to achieve higher lighting intensity values can be seen in Table 5.

Table 5. Lamp replacement recommendations

No.	Room Name	Room area (m2)	Specifications and Analysis				
			Types of Lights	*Quantity*	*Total Power (W)*	*W/m2*	*Description/Status*
1	Finance Sub-Division Room 1	49.14	LED: W15L120 1xLED20S/840	12	199.2	4.05	efficient
2	Evaluation Program Room	96.00	LED: W15L120 1xLED20S/840	25	415.0	4.32	efficient
3	Administration Room	96.00	LED: W15L120 1xLED20S/840	25	415.0	4.32	efficient
4	Meeting Room 1st Floor	34.16	LED: W15L120 1xLED20S/840	9	149.4	4.37	efficient
5	White Wood Lab	22.80	LED: W15L120 1xLED20S/840	6	99.6	4.37	efficient
6	Server Room	23.94	LED: W15L120 1xLED20S/840	8	132.8	5.55	efficient
7	Wood Lab	29.76	LED: W15L120 1xLED20S/840	8	336.0	11.29	efficient
8	Forest Biotechnology Lab Room	97.96	LED: W15L120 1xLED20S/840	24	398.4	4.07	efficient
9	Breeding Room 2	94.80	LED: W15L120 1xLED20S/840	24	398.4	4.20	efficient
10	Breeding Room 3	96.00	LED: W15L120 1xLED20S/840	24	398.4	4.15	efficient

Table 5 outlines recommended lamp replacements for ten rooms using LED lighting (W15L120 1xLED20S/840), focusing on energy efficiency through improved lighting power density. All listed rooms, including offices, laboratories, and meeting areas, are equipped with LED fixtures that offer high efficiency. The total installed power ranges from 99.6 W to 415.0 W, depending on room size and lighting needs. The lighting power density across all rooms remains below 12 W/m², which is considered efficient by modern energy standards. The Server Room, previously marked as inefficient, shows a notable improvement after replacement, achieving 5.55 W/m², now classified as energy efficient. The Wood Lab, although having the highest W/m² value at 11.29, still falls within the efficiency category. This analysis confirms that the recommended LED replacements successfully enhance lighting quality while maintaining low energy consumption, supporting a shift toward more sustainable and cost-effective building utilities. Next, the power comparison before and after lamp replacement is shown in Table 6.

Table 6. Power comparison before and after lamp replacement

No	Room Name	Room area (m2)	Before Replacement (A)		Replacement According to Standard (B)		Replacement Recommendations (C)		Difference (B - C)	
			Total Power (W)	*W/m2*	*Total Power (W)*	*W/m2*	*Total Power (W)*	*W/m2*	*Total Power (W)*	*W/m2*
1	Kuljar Researcher Room	57.24	350.0	6.11	1200.0	20.96	265.6	4.64	934.4	16.32
2	Culture Room 2	36.12	420.0	11.63	420.0	11.63	-	-	-	-
3	Meeting Room	28.62	200.0	6.99	625.0	21.84	149.4	5.22	475.6	16.62
4	Planting Room	32.68	252.0	7.71	378.0	11.57	-	-	-	-
5	Preparation Room	60.52	252.0	4.16	630.0	10.41	-	-	-	-
6	Seed Lab	99.54	336.0	3.38	1512.0	15.19	-	-	-	-
7	Pest Lab 1	23.56	84.0	3.57	504.0	21.39	-	-	-	-
8	Pest Lab 2	23.56	168.0	7.13	504.0	21.39	-	-	-	-
9	Finance Sub-Division Room 1	49.14	504.0	10.26	504.0	10.26	199.2	4.05	304.8	6.21
10	Finance Sub-Division Room 2	47.12	504.0	10.70	504.0	10.70	-	-	-	-
11	Evaluation Service Division	94.80	1008.0	10.36	840.0	8.86	-	-	-	-
12	Evaluation Program Room	96.00	882.0	9.19	840.0	8.75	415.0	4.32	425	4.43
13	Administration Room	96.00	141.0	1.47	1128.0	11.75	415.0	4.32	713	7.43
14	Head's Room	38.44	378.0	9.83	378.0	9.83	-	-	-	-
15	Meeting Room 1st Floor	34.16	168.0	4.92	336.0	9.84	149.4	4.37	186.6	5.47
16	White Wood Lab	22.80	175.0	7.68	750.0	32.89	99.6	4.37	650.4	28.52
17	Server Room	23.94	294.0	12.28	252.0	10.53	132.8	5.55	119.2	4.98
18	Wood Lab	29.76	336.0	11.29	504.0	16.94	-	-	-	-
19	Forest Biotechnology Room	39.69	378.0	9.52	378.0	9.52	-	-	-	-
20	Forest Biotechnology Lab Room	97.96	1008.0	10.29	1512.0	15.43	398.4	4.07	1113.6	11.36
21	Researcher Room	139.80	641.0	4.59	449.0	3.21	-	-	-	-
22	Breeding Room 1	94.80	1008.0	10.63	840.0	8.86	-	-	-	-
23	Breeding Room 2	94.80	756.0	7.97	840.0	8.86	398.4	4.20	441.6	4.66
24	Breeding Room 3	96.00	1008.0	10.50	840.0	8.75	398.4	4.15	441.6	4.6
25	Library	96.00	1008.0	10.50	840.0	8.75	-	-	-	-
TOTAL									5805.8	110.6

The results of the simulation of replacing lamps in several rooms in the DEF Building show a significant decrease in electricity consumption. Based on the data in Table 6, after replacing conventional lamps with LED lamps, most of the rooms experienced total power savings and a decrease in the value of power consumption per square meter (W/m²). For example, in the Forest Biotechnology Lab Room, power consumption before replacement reached 1008 watts with a value of 10.29 W/m². After being simulated using LED lamps, the total power dropped to 398.4 watts or around 4.07 W/m². This means that there was a saving of 609.6 watts in just one room. The same pattern is also seen in Breeding Room 2 and Breeding Room 3, which previously consumed 756 watts and 1008 watts, respectively, then dropped to 398.4 watts after replacement, with savings reaching more than 350 watts per room.

The Server Room, which was previously one of the most wasteful rooms, with a power consumption of 294 watts (12.28 W/m²), after the replacement became only 132.8 watts (5.55 W/m²). This shows that replacing the lamps not only reduces overall energy consumption but also makes the initially wasteful room more efficient. Several other rooms, such as the 1st Floor Meeting Room and the White Wood Lab, also show a similar trend, with a decrease in power consumption of more than 50%.

3.4 Energy Saving Results

Overall, the total power savings from all the simulated rooms in the table reached 5805.8 watts. Assuming the use of lights for 8 hours per day and 20 working days per month, the energy savings that can be achieved are around 928.93 kWh per month, which when converted to electricity costs, is equivalent to savings of Rp 1,362,997.48 per month. This figure shows the great potential for energy efficiency that can be achieved through the implementation of LED-based lighting systems, both technically and economically.

The results obtained in this analysis strengthen the argument that replacing conventional lamps with LEDs not only has an impact on improving lighting quality but also directly contributes to reducing the operational load of buildings. This is in line with what was conveyed by [24] which explains that the use of LED lamps contributes to reducing the operational load of buildings. Therefore, the implementation of recommendations for replacing lamps on a full scale is very worthy of consideration, especially in buildings with long operating hours and many active workspaces, such as government buildings and research facilities.

4 Conclusion

Based on the results of the analysis conducted, it can be concluded that the lighting system in the DEF Building is generally classified as energy efficient, in terms of the ratio of power consumption per square meter. However, the efficiency of power consumption has not been fully accompanied by lighting quality that meets standards. Several rooms show low lighting levels even though their power consumption is small, this indicates that the visual quality aspect still needs to be improved. Simulation of replacing conventional lamps with LED lamps shows a significant decrease in energy consumption in almost all rooms analyzed. The use of LED lamps not only reduces power consumption but also increases the distribution and intensity of lighting that meets the SNI 6197:2020 standard. The total potential energy savings reach 928.93 kWh per month, with an estimated electricity cost savings of around Rp1,362,997.48.

By considering technical, economic, and visual comfort aspects, replacing the lighting system with LED is highly recommended as a strategic step in supporting energy conservation in the building sector, especially for government buildings and research institutions that have high operational loads.

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6 References

[1] K. Naimah *et al.*, “Analysis of Electrical Energy Consumption in Office Buildings of the Institute Technology of Sumatra in Energy Conservation and Efficiency Efforts,” *Jurnal Edukasi Elektro*, vol. 7, no. 2, pp. 181–194, Nov. 2023, doi: 10.21831/jee.v7i2.65003.

[2] K. Naimah, “Analisa Konsumsi Energi dan Sistem Pencahayaan Gedung C Institut Teknologi Sumatera,” *Journal of Energy and Electrical Engineering*, vol. 2, no. 2, Apr. 2021, doi: 10.37058/jeee.v2i2.2607.

[3] Vicky Prasetia, Supriyono, and Purwiyanto, “Evaluasi Sistem Pencahayaan Gedung Pendidikan Perkuliahan Sesuai Standar Nasional Indonesia (SNI),” *Infotekmesin*, vol. 13, no. 2, pp. 308–313, Jul. 2022, doi: 10.35970/infotekmesin.v13i2.1546.

[4] C. Mamahit and P. Pangestu, “Desain dan Analisis Pencahayaan Gedung Bengkel Universitas Negeri Manado,” *ELECTRON Jurnal Ilmiah Teknik Elektro*, vol. 5, no. 1, pp. 46–52, May 2024, doi: 10.33019/electron.v5i1.72.

[5] M. Krarti, *Energy audit of building systems: an engineering approach*. CRC press, 2020.

[6] S. Riyadi and J. M. Tambunan, “Analisis Peningkatan Efisiensi Penggunaan Energi Listrik pada Sistem Pencahayaan dan Air Conditioning di Gedung Graha Mustika Ratu,” in *Prosiding Seminar Nasional Energi & Teknologi (Sinergi)*, 2018, pp. 107–121.

[7] M. Hemmerling, M. Seegers, and D. Witzel, “Calculation of energy saving potential for lighting with DIALux evo,” *Energy Build*, vol. 278, p. 112475, Jan. 2023, doi: 10.1016/j.enbuild.2022.112475.

[8] A. M. Al-Ghaili, H. Kasim, N. M. Al-Hada, M. Othman, and M. A. Saleh, “A review: buildings energy savings-lighting systems performance,” *IEEE Access*, vol. 8, pp. 76108–76119, 2020.

[9] E. Iddio, L. Wang, Y. Thomas, G. McMorrow, and A. Denzer, “Energy efficient operation and modeling for greenhouses: A literature review,” *Renewable and Sustainable Energy Reviews*, vol. 117, p. 109480, 2020.

[10] Badan Standar Nasional, *Konservasi energi pada sistem pencahayaan*. 2020.

[11] N. Pratiwi and A. G. Djafar, “Analysis of Lighting Performance in the Hall of the Faculty of Engineering, State University of Gorontalo by using the DIALux Evo 9.0 Simulation,” *IOP Conf Ser Earth Environ Sci*, vol. 738, no. 1, p. 012032, Apr. 2021, doi: 10.1088/1755-1315/738/1/012032.

[12] I. Fryc, M. Listowski, R. Supronowicz, and C. Martinsons, “Selecting Energy-Efficient LED Retrofits with Optimal Color Qualities for New and Refurbished Buildings,” *Energies (Basel)*, vol. 18, no. 1, p. 112, Dec. 2024, doi: 10.3390/en18010112.

[13] S. Gorgulu and S. Kocabey, “An energy saving potential analysis of lighting retrofit scenarios in outdoor lighting systems: A case study for a university campus,” *J Clean Prod*, vol. 260, p. 121060, 2020.

[14] O. Sadeghian *et al.*, “A comprehensive review on energy saving options and saving potential in low voltage electricity distribution networks: Building and public lighting,” *Sustain Cities Soc*, vol. 72, p. 103064, Sep. 2021, doi: 10.1016/j.scs.2021.103064.

[15] Z. He, T. Hong, and S. K. Chou, “A framework for estimating the energy-saving potential of occupant behaviour improvement,” *Appl Energy*, vol. 287, p. 116591, Apr. 2021, doi: 10.1016/j.apenergy.2021.116591.

[16] N. Kunwar, K. S. Cetin, U. Passe, X. Zhou, and Y. Li, “Energy savings and daylighting evaluation of dynamic venetian blinds and lighting through full-scale experimental testing,” *Energy*, vol. 197, p. 117190, Apr. 2020, doi: 10.1016/j.energy.2020.117190.

[17] A. Kerem, “Assessing the electricity energy efficiency of university campus exterior lighting system and proposing energy-saving strategies for carbon emission reduction,” *Microsystem Technologies*, vol. 28, no. 12, pp. 2623–2640, 2022.

[18] M. Awang *et al.*, “Assessment of energy saving potential and lighting system in teaching building,” *Journal of Advanced Research in Fluid Mechanics and Thermal Sciences*, vol. 65, no. 1, pp. 159–169, 2020.

[19] P. Belany, P. Hrabovsky, and Z. Kolkova, “Combination of lighting retrofit and life cycle cost analysis for energy efficiency improvement in buildings,” *Energy Reports*, vol. 7, pp. 2470–2483, Nov. 2021, doi: 10.1016/j.egyr.2021.04.044.

[20] D. Zheng, L. Yu, and L. Wang, “Research on Large-Scale Building Energy Efficiency Retrofit Based on Energy Consumption Investigation and Energy-Saving Potential Analysis,” *Journal of Energy Engineering*, vol. 145, no. 6, Dec. 2019, doi: 10.1061/(ASCE)EY.1943-7897.0000618.

[21] A. Powers and M. Saad, “Building Energy Use: Modeling and Analysis of Lighting Systems—A Case Study,” *Sustainability*, vol. 14, no. 20, p. 13181, Oct. 2022, doi: 10.3390/su142013181.

[22] P. Mandal, D. Dey, and B. Roy, “Optimization of luminaire layout to achieve a visually comfortable and energy efficient indoor general lighting scheme by Particle Swarm Optimization,” *LEUKOS*, vol. 17, no. 1, pp. 91–106, Jan. 2021, doi: 10.1080/15502724.2018.1533853.

[23] O. Sadeghian *et al.*, “A comprehensive review on energy saving options and saving potential in low voltage electricity distribution networks: Building and public lighting,” *Sustain Cities Soc*, vol. 72, p. 103064, 2021.

[24] S. Bunjongjit and A. Ngaopitakkul, “Feasibility study and impact of daylight on illumination control for Energy-saving lighting systems,” *Sustainability*, vol. 10, no. 11, p. 4075, 2018.

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