

Evaluation of Energy Efficiency and Illuminance Performance of LED Lighting Systems in Office Spaces Using DIALux Simulation

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Abstract: Energy efficiency in office buildings has become a critical issue due to increasing electricity consumption, particularly in lighting systems that operate continuously. Inefficient lighting design can lead to excessive energy use, higher operational costs, and reduced sustainability performance in commercial buildings. **Objective:** This study aims to analyze the implementation of Light Emitting Diode (LED) technology to improve energy efficiency in office lighting systems using DIALux simulation, while ensuring compliance with standard illumination requirements. **Method:** This research employs a quantitative descriptive approach supported by simulation modeling. Data were collected through field observation, illumination measurement using a lux meter, and documentation of room specifications. The analysis was conducted using DIALux software to evaluate illuminance levels, light distribution, and energy consumption based on office lighting standards. **Findings:** The results indicate that the LED lighting system achieves an average illuminance of 340 lux, which meets the SNI 6197:2011 standard (300–500 lux), with a uniformity ratio of 0.68 indicating adequate light distribution and visual comfort. The system consumes 36 kWh per month, which is more than 50% lower than conventional fluorescent (TL) lighting systems. **Implications:** The findings suggest that LED lighting systems can provide efficient and compliant lighting solutions while significantly reducing energy consumption and operational costs. This supports the implementation of energy-efficient and sustainable building practices. **Originality:** The originality of this study lies in its integrated approach that combines room characteristics, LED configuration, and DIALux simulation to evaluate lighting performance and energy efficiency simultaneously, offering a practical framework for office lighting design.

Keywords: LED Lighting; Energy Efficiency; Office Lighting; Dialux Simulation; Illuminance

INTRODUCTION

Modern multi-story office buildings are characterized by high energy consumption due to prolonged daily operational hours, particularly in primary areas such as the first floor, which typically accommodates the highest level of activity. In such environments, lighting systems play a critical role in supporting administrative tasks, employee mobility, visual comfort, and overall productivity. If lighting systems are not properly designed according to spatial requirements and standards, they can lead to significant energy waste and

increased operational costs. According to Hasibuan improper lighting system implementation can result in substantial energy inefficiencies in public and commercial buildings, including office spaces (Hasibuan et al., 2020). In large-scale buildings with diverse functional areas, the need for an efficient lighting system becomes increasingly essential to ensure adequate illumination while minimizing energy consumption.

Field observations further indicate that energy inefficiency in office buildings is not solely determined by the type of lighting used, but also by how lighting systems are operated. In high-mobility areas such as lobbies, corridors, and shared workspaces, lights are often left on even when occupancy is low or natural lighting is sufficient. This condition highlights the potential for energy savings through adaptive lighting management systems. Afrizal emphasized that energy savings through efficient lighting management are particularly important in large buildings with intensive activity (Afrizal, 2022). Additionally, improving energy efficiency in commercial buildings is part of green technology implementation that supports sustainable development (Nugroho et al., 2024). Therefore, analyzing the implementation of energy-efficient lighting technologies in office environments is crucial from both academic and practical perspectives.

From a literature perspective, the first group of studies focuses on the use of Light Emitting Diode (LED) technology as a solution for energy-efficient lighting systems. Compared to incandescent and CFL lamps, LEDs are widely recognized for their lower power consumption, longer lifespan, and higher luminous efficacy. Hasibuan demonstrated that LED implementation in lighting systems can significantly reduce energy consumption (Hasibuan et al., 2020). Similarly, Saputro explained that LED lighting in buildings provides more efficient energy usage compared to conventional lighting systems (Saputro et al., 2013). Furthermore, Husnayain through a comparative analysis of LED, CFL, and incandescent lamps in office lighting systems, found that LEDs outperform other lighting types in terms of efficiency and lighting quality (Husnayain et al., 2023). These studies collectively confirm that LED technology is a key component in achieving energy-efficient building systems.

The second group of studies emphasizes the role of automatic control systems in improving lighting energy efficiency. These systems regulate lighting operation based on occupancy and natural light conditions using motion sensors, light sensors, and dimming systems. Saputra stated that sensor-based automatic control systems can significantly reduce energy consumption by ensuring that lighting is only used when necessary (Saputra

& Surapati, 2024). Pradanugraha and Sudiarto also highlighted that dimming systems enhance lighting efficiency by adjusting illumination levels according to real-time requirements (Pradanugraha & Sudiarto, 2022). In addition, Wiraguna and Purwanto demonstrated that the integration of digital sensor technologies in office buildings can support more intelligent and responsive energy management (Wiraguna & Purwanto, 2024). These findings indicate that energy efficiency is influenced not only by the lighting technology itself but also by the control systems applied.

The third group of studies addresses energy efficiency from a broader perspective, including energy audits, technical evaluations, and the application of lighting standards. Widayati analyzed energy-saving potential in multi-story office buildings by considering interdependent energy variables (Widayati, 2021). Ningrum and Yuliani emphasized the importance of energy efficiency strategies in supporting sustainable campus development (Ningrum & Yuliani, 2024), while Moerni (2024) examined the implementation of energy-efficient building concepts in architectural design. Furthermore, Nugroho demonstrated that energy audits can serve as a basis for improving operational efficiency in buildings (Nugroho et al., 2024), including lighting systems. However, most of these studies focus on building-level efficiency without specifically examining the integrated relationship between LED lighting configuration, light distribution in office spaces, and compliance with illumination standards using DIALux simulation. This gap forms the foundation for the present study.

Based on the field conditions and identified research gaps, this study aims to analyze the implementation of LED technology for energy efficiency in office lighting systems using DIALux simulation. The analysis focuses on evaluating illumination levels, light distribution, and energy consumption within an office space to determine whether the selected LED configuration meets the required lighting standards while achieving optimal energy efficiency. This study is expected to provide practical contributions to the design of efficient and economical office lighting systems, as well as to strengthen the application of simulation tools in evaluating indoor lighting performance.

The argument of this study is that the implementation of LED lighting systems in office spaces, when designed based on technical room parameters and evaluated using DIALux simulation, will be able to meet standard illumination requirements while significantly reducing energy consumption compared to conventional lighting systems. In other words, LED technology is expected to have a positive impact on improving energy efficiency

without compromising lighting quality. This argument is supported by previous findings indicating that LEDs offer higher efficiency than conventional lighting systems ([Hasibuan et al., 2020](#); [Husnayain et al., 2023](#)), and that their performance can be further optimized when integrated with technical evaluation approaches and automated control systems in modern buildings ([Saputra & Surapati, 2024](#); [Wiraguna & Purwanto, 2024](#))

RESEARCH METHOD

The unit of analysis in this study is the office lighting system applied in a first-floor office space of a multi-story office building. The focus of the study is the performance of the lighting system in terms of illumination level, light distribution, and energy consumption. In this context, the lighting system is examined as a technical object consisting of lamp type, number of lamps, room dimensions, surface reflectance, and operational duration. The study specifically evaluates the implementation of LED lighting technology in office spaces to determine its suitability with lighting standards and its potential contribution to energy efficiency.

This study employs a quantitative descriptive design supported by technical simulation. This design was chosen because the research aims to measure and evaluate lighting performance objectively based on numerical indicators such as illuminance level, uniformity ratio, power consumption, and energy cost. A quantitative approach is appropriate because the study relies on measurable lighting parameters and standard-based assessment. In addition, DIALux simulation is used to support the analysis because it enables the researcher to model lighting conditions, estimate illumination levels, and assess the suitability of the selected lighting configuration before implementation or redesign.

The data used in this study consist of both primary and secondary data. Primary data include field measurements of illumination level obtained from the observed office space using a lux meter or illuminometer. This instrument is used to measure illuminance (E) on a surface so that room lighting conditions can be quantitatively evaluated according to applicable standards. Sugistoro emphasized that the use of a lux meter provides an objective representation of whether a room is sufficiently bright or dim ([Razu et al., 2025](#)). Secondary data include room specifications, lighting standards for office spaces, lamp characteristics, and technical parameters required in the DIALux simulation, such as room dimensions, ceiling height, and the reflectance values of ceiling, wall, and floor surfaces. Primary data include field measurements of illumination level obtained using a lux meter

(illuminometer). This instrument is used to measure illuminance (E) on a surface so that room lighting conditions can be quantitatively evaluated according to applicable standards.



Figure 2. Lux meter (illuminometer) used for measuring illumination level

The data collection process was carried out through several techniques. First, direct observation was conducted to identify the existing lighting conditions in the office space and to examine the general characteristics of the room. Second, illumination measurements were performed using a lux meter to obtain actual data on lighting intensity. Third, documentation and literature study were conducted to collect supporting technical information related to office lighting standards, LED lamp specifications, and building energy efficiency principles. In addition, supporting information was obtained from the building manager regarding lighting operation patterns and room function. These data were then used as the basis for simulation modeling in DIALux. The illuminance calculation in lighting analysis refers to the illuminance equation:

$$E = \frac{\Phi}{A}$$

where E is illuminance (lux), Φ is luminous flux (lumen), and A is the illuminated area in square meters. Besides illuminance calculation, the analysis also considers wall, ceiling, and floor reflectance, since these factors affect light distribution and visual comfort in the room.

The data analysis was carried out in several stages. First, the measured illumination data were compared with office lighting standards to determine whether the existing lighting condition was appropriate. Second, the room and lighting specifications were modeled in DIALux to simulate the lighting distribution, average lux level, minimum and

maximum lux values, and uniformity ratio. Third, the installed power, daily operating hours, monthly energy consumption, and estimated electricity cost were calculated to evaluate energy efficiency. Finally, the simulation and calculation results were interpreted descriptively to assess whether the LED lighting configuration was capable of meeting illumination standards while reducing energy use compared to conventional lighting systems. Based on this analysis, conclusions and recommendations were formulated regarding the implementation of LED technology for office lighting efficiency.

RESULT

Office Lighting System Characteristics and Input Data

The first result concerns the physical and technical characteristics of the office room used as the object of simulation. The simulated room represents a small-to-medium office space intended for administrative activities. The parameters entered into the DIALux software include room dimensions, room height, and the reflectance values of the ceiling, walls, and floor, because these variables directly influence light distribution and illuminance performance. Based on SNI 6197:2011, the required illuminance standard for office spaces ranges from 300 to 500 lux, depending on the type of work activity performed in the room. Figure 4 presents the office room model developed in DIALux, while Table 1 summarizes the room specifications used in the simulation.

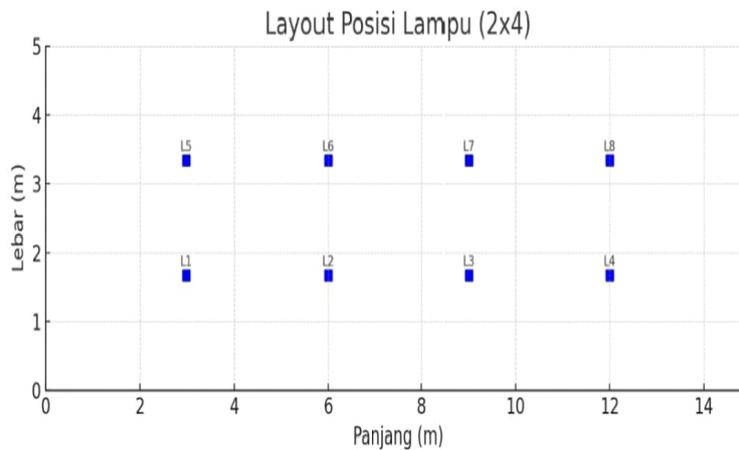


Figure 4. Lighting simulation model using DIALux software

Table 1. Room Specification Data

No	Parameter	Specification
1	Room Size	Length 15 m × Width 5 m = 75 m ²

No	Parameter	Specification
2	Room Height	2 m
3	Ceiling Color	White (Reflectance 80%)
4	Wall Color	Bright white (Reflectance 70%)
5	Floor Color	Light gray (Reflectance 50%)
6	Room Function	Office

In addition to room characteristics, the lighting input data were also processed to estimate the monthly energy requirement of the proposed LED system. The lighting configuration consists of eight LED lamps, each rated at 15 W, resulting in a total installed power of 120 W. With an operating duration of 10 hours per day, the monthly energy consumption reaches 36 kWh, with an estimated electricity cost of Rp 50,400.

Table 2. Processed Energy Consumption Data

No	Parameter	Value
1	Lamp Type	LED 15 W
2	Number of Lamps	8 units
3	Total Power	$8 \times 15 \text{ W} = 120 \text{ W}$
4	Daily Operating Time	10 hours/day
5	Monthly Energy Consumption	$120 \text{ W} \times 10 \text{ hours} \times 30 \text{ days} = 36,000 \text{ Wh} = 36 \text{ kWh}$
6	Energy Cost (Rp 1,400/kWh)	$36 \times 1,400 = \text{Rp } 50,400$

Restated simply, the room used in this study is a 75 m² office room with high-reflectance interior surfaces, which support good light distribution. The installed lighting system consists of eight 15 W LED lamps operating for 10 hours daily, producing a relatively low total power demand of 120 W and a monthly energy cost that remains economically manageable.

Several patterns can be identified from these data. First, the room geometry is elongated (15 m × 5 m), which means lighting distribution must be arranged carefully to avoid uneven illumination. Second, the high reflectance values of the ceiling and walls indicate favorable conditions for light diffusion within the room. Third, the selected LED configuration uses relatively low installed power for a 75 m² office area. Fourth, the calculated monthly energy use of 36 kWh suggests that the system has potential to support efficient operation even before comparison with conventional lamps is made.

These findings imply that the simulation was carried out under technically relevant and realistic room conditions. The room specification data provide a valid basis for evaluating whether the selected LED configuration can meet office lighting standards while maintaining energy efficiency. This first evidence establishes the structural and technical context of the study.

Lighting Performance Based on DIALux Simulation

The second result concerns the lighting performance generated by the simulated LED system. The simulation was conducted using DIALux evo to evaluate the average illuminance, minimum and maximum illuminance values, and light uniformity in the office room. These indicators are important because the objective of the study is not only to reduce energy consumption, but also to ensure that the lighting system complies with office lighting standards and provides acceptable visual comfort. The results of the simulation are presented in Figure 5 and Table 3.

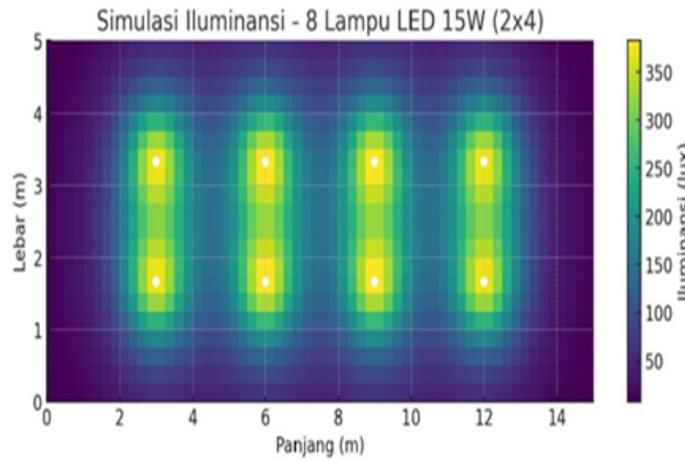


Figure 5. Result of office lighting simulation

Table 3. DIALux Simulation Results

Parameter	Simulation Result
Average Lux	340 lux
Minimum Lux	280 lux
Maximum Lux	370 lux
Uniformity Ratio	0.68
Visual Comfort	Good
Ceiling Reflectance	80% (white)
Wall Reflectance	70% (bright white)
Floor Reflectance	50% (light gray)

To simplify these results, the simulation shows that the office room receives an average illuminance of 340 lux, which falls within the SNI 6197:2011 standard range of 300–500 lux for office activities. Although the minimum illuminance is 280 lux, the maximum value reaches 370 lux, and the overall light distribution remains adequately balanced with a uniformity ratio of 0.68. The visual comfort level is also categorized as good.

From these findings, several tendencies can be observed. First, the average illuminance complies with the required office standard, indicating that the overall lighting level is sufficient for administrative tasks. Second, the difference between minimum and maximum lux values is not excessive, suggesting that the lamp arrangement provides relatively stable light coverage across the room. Third, the uniformity ratio of 0.68 indicates that illumination differences between points are still within an acceptable range for office use. Fourth, the reflectance values of the room surfaces appear to support the performance of the LED system by helping redistribute light more effectively.

The meaning of these results is significant for the study because they show that energy-efficient lighting does not necessarily compromise lighting quality. The simulation confirms that the selected LED configuration is capable of satisfying technical lighting requirements in office spaces. This evidence supports the idea that DIALux simulation can be used effectively as a planning tool to verify compliance with lighting standards before implementation.

Energy Efficiency and Comparison with Conventional Lighting

The third result addresses the energy efficiency of the LED lighting system and its comparison with conventional fluorescent TL lamps. Based on the processed data, the LED system uses a total installed power of 120 W. Under the assumption of 10 operating hours per day, the monthly energy consumption is 36 kWh, with an estimated electricity cost of Rp 50,400. For comparison, if the room used eight TL lamps rated at 36 W each, the total installed power would become 288 W, with monthly energy consumption of 86.4 kWh and an electricity cost of Rp 120,960. The comparison is summarized in Table 4.

Table 4. Comparison of LED and TL Lighting Systems

Parameter	LED System	TL System
Lamp Type	LED 15 W	TL 36 W
Number of Lamps	8 units	8 units
Total Power	120 W	288 W

Parameter	LED System	TL System
Daily Operating Time	10 hours/day	10 hours/day
Monthly Energy Consumption	36 kWh	86.4 kWh
Monthly Energy Cost	Rp 50,400	Rp 120,960

In simpler terms, the LED system consumes far less electricity than the TL system while still meeting the required lighting standard. The LED system requires only 36 kWh per month, whereas the TL system would require 86.4 kWh under the same operating duration. This means that the LED lighting configuration significantly reduces both energy use and monthly electricity expenses.

Several important patterns emerge from this comparison. First, the total installed power of the TL system is more than twice that of the LED system. Second, the difference in monthly energy use is substantial, indicating that lamp technology directly affects operational efficiency. Third, the monthly electricity cost of the TL system is considerably higher, showing that conventional lamps impose a greater financial burden on building operation. Fourth, despite lower power consumption, the LED system still achieves compliant lighting performance based on the DIALux results.

These findings indicate that the implementation of LED lighting technology is not only technically feasible but also economically advantageous. The results strengthen the study's main argument that LED lighting can improve office lighting efficiency without reducing illuminance quality. Therefore, LED technology can be considered a practical solution for office buildings seeking to reduce energy consumption, lower operating costs, and support sustainable building management.

DISCUSSION

This study demonstrates that the implementation of LED lighting systems in office spaces, supported by DIALux simulation, is capable of achieving both adequate illumination and energy efficiency. The results indicate that the average illuminance level of 340 lux meets the SNI 6197:2011 standard for office environments (300–500 lux), while the uniformity ratio of 0.68 reflects a relatively even distribution of light. In addition, the calculated monthly energy consumption of 36 kWh shows that the LED system operates with relatively low energy demand. When compared with conventional TL lamps, the LED system reduces energy consumption by more than 50%, confirming its efficiency advantage in both technical and economic aspects.

The findings can be explained by the inherent characteristics of LED technology and the influence of room parameters on lighting performance. LEDs are known for their high luminous efficacy, meaning they can produce sufficient light output with lower electrical power. In this study, the use of eight 15 W LED lamps was sufficient to meet the required illumination standard due to the combined effect of efficient light output and favorable room conditions. The reflectance values of the ceiling (80%), walls (70%), and floor (50%) contributed to improved light distribution by reflecting light throughout the room. Furthermore, the elongated room geometry (15 m × 5 m) required careful lamp placement, which was effectively optimized through DIALux simulation. This explains why adequate illumination and good uniformity were achieved despite the relatively low installed power.

When compared to previous studies, the results of this research are consistent with findings that highlight the efficiency of LED lighting systems. Hasibuan and Husnayain reported that LED lamps offer superior energy efficiency and lighting performance compared to conventional lighting technologies ([Hasibuan et al., 2020](#); [Husnayain et al., 2023](#)). Similarly, Saputro confirmed that LED implementation can significantly reduce energy consumption in building lighting systems ([Saputro et al., 2013](#)). In terms of lighting control, studies by Saputra and Wiraguna and Purwanto emphasized the importance of integrating sensor-based systems to further enhance energy savings ([Saputra & Surapati, 2024](#); [Wiraguna & Purwanto, 2024](#)). However, the novelty of this study lies in its integrated approach, which combines room characteristics, LED configuration, and DIALux-based simulation to evaluate both lighting performance and energy efficiency simultaneously in an office context. This integration provides a more comprehensive understanding compared to studies that examine these aspects separately.

The results of this study have important implications for the broader understanding of energy-efficient building design. From a technical perspective, the findings confirm that energy efficiency does not necessarily compromise lighting quality. Instead, with proper design and simulation, it is possible to achieve both objectives simultaneously. From a practical perspective, the study supports the adoption of LED lighting systems as part of sustainable building strategies. The ability to meet illumination standards while reducing energy consumption aligns with global efforts to promote green buildings and reduce carbon emissions. Thus, the study contributes to the growing body of knowledge on energy-efficient lighting systems and their role in sustainable development.

From a reflective perspective, the implementation of LED lighting systems offers several advantages, including reduced energy consumption, lower operational costs, longer lamp lifespan, and improved visual comfort. However, there are also potential limitations to consider. The effectiveness of the system depends on proper design, accurate simulation, and appropriate installation. Without careful planning, issues such as uneven lighting distribution or insufficient illumination in certain areas may still occur. Additionally, while LED systems are energy-efficient, their initial installation cost may be higher compared to conventional lighting systems, which could be a consideration for building managers. Therefore, both the benefits and limitations must be taken into account when implementing such systems.

Based on these findings, several practical actions can be recommended. Building managers and designers should prioritize the use of LED lighting systems in office environments due to their proven efficiency and performance. In addition, the use of simulation tools such as DIALux should be integrated into the design process to ensure that lighting configurations meet technical standards before implementation. Furthermore, combining LED lighting with automatic control systems, such as motion sensors and daylight sensors, can further enhance energy savings. Policymakers and stakeholders in the construction and building management sectors are also encouraged to promote energy-efficient lighting standards and provide incentives for adopting sustainable technologies. These actions will contribute to reducing energy consumption, lowering operational costs, and supporting environmentally sustainable building practices.

CONCLUSION

This study concludes that the implementation of LED lighting systems in office spaces, supported by DIALux simulation, is able to meet illumination standards while achieving significant energy efficiency. The simulation results indicate that the average illuminance level of 340 lux complies with the SNI 6197:2011 standard for office environments (300–500 lux), with a uniformity ratio of 0.68 indicating relatively even light distribution and acceptable visual comfort. In addition, the LED lighting configuration, consisting of eight 15 W lamps, results in a monthly energy consumption of 36 kWh, which is substantially lower than conventional TL lighting systems. These findings highlight that properly designed LED lighting systems can provide sufficient lighting performance while reducing operational energy demand.

The main scientific contribution of this study lies in its integrated analytical approach that combines room characteristics, LED configuration, and DIALux-based simulation to evaluate both lighting performance and energy efficiency simultaneously. Unlike previous studies that tend to examine lighting technology, control systems, or energy efficiency separately, this research provides a more comprehensive framework by linking technical parameters of the room with simulation-based performance analysis. This contribution offers practical value for engineers, designers, and building managers in developing energy-efficient lighting systems that are both technically compliant and economically beneficial.

Despite its contributions, this study has several limitations. The analysis is based on a single room configuration and relies primarily on simulation results without direct experimental validation under real operating conditions. In addition, dynamic factors such as natural daylight variation, user behavior, and the implementation of automatic control systems were not fully explored. Future research is recommended to incorporate field measurements, examine different room configurations, and integrate smart lighting control technologies to provide a more comprehensive and adaptive evaluation of energy-efficient lighting systems in office buildings.

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