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Application of Dialux EVO in Retrofitting Lighting Systems: Enhancing Energy Savings and Regulatory Compliance in Educational Spaces

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Abstract

The current lighting system of the Faculty of Mechanical Technology and Engineering (FTKM) “Green” Building on floors 1 and 2 has remained the same from more than 10 years ago, which overall still uses compact fluorescent lamps (CFL). There are plenty of research that has utilized DIALux Evo 12.0 in retrofitting lighting systems of buildings, and that from this software we are able to simulate the existing conditions, find ways to improve the lighting system for saving energy, comply to national standards, and acquire quantitative results. This investigation aims to retrofit the current lighting system of the FTKM “Green” Building floors 1 and 2 using DIALux Evo 12.0. The existing lighting system is first reconstructed into DIALux Evo, hence quantitative and qualitative data such as compliance to standard status, average lux, lighting power density can be calculated and recorded. This lighting system is then redesigned to minimize power consumption through rearrangement of lamp positions and lamp type replacement. The state of the lighting system before and after is compared. Analysis of the simulation demonstrated that replacing CFLs with LED lamps has significantly reduced the energy consumption for the lighting system. Therefore, the results have indicated that the application of DIALux Evo 12.0 in the effort of minimizing energy consumption of an existing lighting system is applicable. This investigation however did run into some limitations such as the existing blinders’ dimensions was unable to be recreated due to the software’s construction tools shortcomings. Further research is required to overcome this limitation using other methods to achieve more accurate analysis.

Keywords: DIALux Evo, Lighting System, Retrofitting, Reduce Energy Consumption, National Standards, Energy Analysis, Lux Standards, Dosh 2018, Ms1525 2019.Producers

Introduction

The building is a hub for education, housing lecture rooms, a library and offices for UTeM occupants, and floors 1 and 2 are primarily student lecture rooms with public spaces such as toilets, stairs, lobbies, and corridors. DIALux evo is a software that provides a wide range of tools and settings for creating lighting scenes that simulates real scenarios and produces various beneficial calculations. The DIALux software is acknowledged for providing, in the majority of cases, dependable and accurate results in the calculation of specific lighting quantities (Ali et al., 2020). Lazuardy from Department of Occupational Safety and Health, (2018), states that DIALux evo can replicate a building, outdoor space, or rooms as well as simulate and analyze lighting system's performance in specified geographical locations and object environments, producing measurement results in numerical, graphical and visual format. Since older versions such as such DIALux evo 3, result calculations such as light output ratio, total luminous flux, total load, room height, quantity of lights, reflection factor, average lux, and lux minimum and maximum are provided (Ember & Energy Institute, 2024).

The investigation focuses on optimizing lighting requirements for FTKM "Green" building floors 1 and 2 using the simulation software, DIALux Evo 12.0 which includes the importance of effective lighting in educational spaces, enhance standard regulation, productivity, and energy efficiency. Lighting technology stands as a prominent consumer of electricity, accounting for over 15 percent of total electricity consumption. During peak periods, this share can escalate to nearly a quarter of the overall electricity demand (Kamaruddin et al., 2016). Kralikova et al. (2015) emphasized the imperative for a comprehensive policy and strategy to foster sustainable resources and diminish carbon emissions, thereby steering Malaysia towards sustainable energy consumption. The Malaysian standard lighting requirement (MS1525:2019) is also considered in determining the compliance of the lighting system to the interior building lighting power density requirements.

Literature Review

Energy efficiency in building lighting systems has been a focal point of sustainable development due to its significant impact on energy consumption and carbon emissions. Lighting technology alone contributes to over 15% of global electricity use, with this figure reaching nearly 25% during peak periods (Ali et al., 2020). The transition from traditional Compact Fluorescent Lamps (CFLs) to energy-efficient Light Emitting Diodes (LEDs) has gained traction as a sustainable alternative, offering longer lifespan, reduced power consumption, and better luminous efficacy (Kralikova et al., 2015). Studies have consistently shown that retrofitting older lighting systems in buildings can lead to substantial reductions in energy costs and emissions while improving illumination quality (Kamaruddin et al., 2016). In Malaysia, compliance with standards such as MS1525:2019 underscores the importance of optimizing lighting systems to align with energy and lux requirements (Department of Occupational Safety and Health, 2018).

Simulation tools like DIALux Evo have become invaluable for evaluating and optimizing lighting systems in a virtual environment. This software provides detailed lighting calculations, such as light power density (LPD), lux levels, and compliance with local and international standards (Kralikova et al., 2015; Nurrohman et al., 2021). Researchers like Kamaruddin et al. (2016) and Nurrohman et al. (2021) have demonstrated the efficacy of DIALux Evo in simulating lighting designs for various applications, from classrooms to industrial settings (Skarżyński &

Rutkowska, 2020; Tenaga Nasional Berhad, 2014). By replicating real-world lighting conditions and incorporating factors like daylight and room dimensions, DIALux Evo facilitates precise energy analysis and optimization. Such tools enable decision-makers to identify energy-saving opportunities and predict the impact of retrofitting measures before actual implementation.

The use of LED lighting systems in educational facilities has been extensively studied due to the dual benefits of energy efficiency and enhanced learning environments. Effective lighting plays a crucial role in maintaining visual comfort, improving productivity, and ensuring safety for occupants (Veitch & Galasiu, 2012). Studies indicate that LED retrofitting projects in classrooms and offices not only reduce operational costs but also ensure adherence to occupational safety standards, such as the Guidelines on Occupational Safety and Health for Lighting at Workplace 2018 (Department of Occupational Safety and Health, 2018). For instance, large-scale retrofitting projects have reported energy savings of up to 60%, with carbon emissions significantly reduced through the adoption of LEDs (Maines, 2021). These findings highlight the alignment of lighting retrofitting with global sustainability goals.

Despite these advancements, certain challenges persist, particularly in integrating existing architectural constraints with modern lighting designs. Limitations in simulation tools, such as the inability to recreate specific elements like blinders, can affect the accuracy of retrofitting analysis. Researchers like Skarżyński and Rutkowska (2020) have noted these challenges, emphasizing the need for complementary approaches to achieve more comprehensive evaluations. Additionally, ensuring that retrofitted systems maintain compliance with both energy standards and visual performance criteria remains a critical area of research. This paper contributes to the ongoing discourse by demonstrating the application of DIALux Evo in retrofitting educational buildings, providing a case study that integrates simulation analysis, compliance evaluation, and energy savings.

Methodology

Other than utilizing the simulation of lighting system using DIALux Evo 12.0, we also applied the measurement for general lighting method by the Guidelines on Occupational Safety and Health for Lighting at Workplace 2018 (GOSHLW 2018). This is to compare the simulation of average lux and onsite average lux measurements for better accuracy of the simulation. Measurement for general lighting uses a luxmeter and the dimensions of the calculation space. Room index, RI, is acquired first to know the quantity of lux recording points for the room. hence the lux average of the room is obtained [6]. The luxmeter average lux reading is also compared to the GOSHLW 2018 recommended average lux as a standard to maintain occupant comfort and safety.

The construction of the floors are based on a floorplan file inserted into DIALux and scaled 1:1 ratio. The simulation also includes daylight settings in the calculation. Simulation of the lighting system is then compared to the luxmeter average lux measurements and to obtain a more accurate analysis, percentage error of less than 5% is maintained. After rectifying the existing simulation results, retrofitting can be done. Luminaires that are not available in the DIALux catalogue have been replaced with luminaires available with the closest properties. All working calculation planes in the simulation is at 0.8m above floor surface. Figure 1 below illustrates the methodology flow for this investigation.

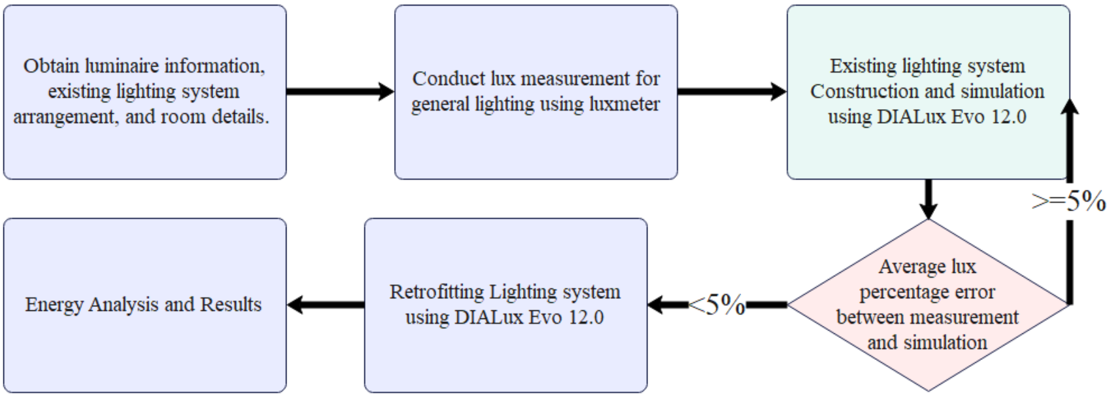


Fig. 1 Investigation of lighting system flowchart

Results and Discussion

Results from luxmeter are calculated, showing the percentage of rooms and areas that comply to their corresponding average lux recommendation by GOSHLW. Simulation that has been designed based on the existing lighting system, and rectified to match until an acceptable amount related to the luxmeter readings. Table 1 below shows the details collected about the site for investigation. It is a total of 34 rooms or areas that are most common areas for students. In some areas such as the main lobby and corner stairs, lighting is heavily reinforced by natural daylight due to the design of the building, having large laminated windows as walls. Although that is not the same condition as most classrooms due to large blinders used for façade system that blocks most daylight in all classrooms. Table 2 and Figure 2 shows related important details of the luminaires in the simulation.

Table 1

Basic Details of the Site

Total rooms/areas	Total lamps	Types of luminaires
38	363	6

Table 2

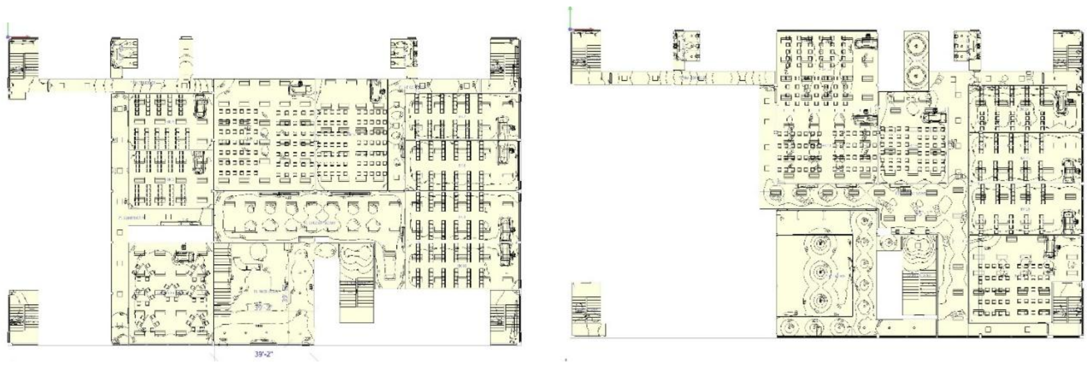
Existing Lighting System Luminaires

Luminaire	Lamp Type	Total Lamps	Area designation	Luminous Efficacy (lm/W)
RIDI 4FTX2FT	CFL	270	Classrooms, lobbies	87.5
K418.P-A EVG(2FTX2FT)	CFL	42	Corridors, stairs	49.8
ECHO DOWNLIGHT	LED	39	Lobbies	96.5
CO2 154 (4FT T5)	CFL	4	Toilets	65.9
PHILIPS 4FT	LED	5	Mid stairs	124.6
ERIS SPOTLIGHT	LED	3	Lobby	131.6

Φ_{total}	P_{total}	Luminous efficacy
1934003 lm	22570.5 W	85.7 lm/W

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
42	ES-SYSTEM	7150401	K418.P-A EVG	36.0 W	1792 lm	49.8 lm/W
4	ES-SYSTEM	6846050	CO2 154	60.0 W	3954 lm	65.9 lm/W
3	Petridis	88453302_	ERIS_4_SYM._LED_CHIP_19W_NEUTRAL_MEDIUM	38.0 W	5002 lm	131.6 lm/W
5	Philips		SM136V LED43S/840 OC WIA W20L120	34.5 W	4300 lm	124.6 lm/W
270	RIDI	0860438	L 36w865	72.0 W	6300 lm	87.5 lm/W
39	Regent	1008.8810 - ECHO210 DL LED2700-9 40 RSR 60 WH DALI E1h	Recessed downlight Echo 210 28W 2700lm CRI > 90 4000K white	28.0 W	2703 lm	96.5 lm/W

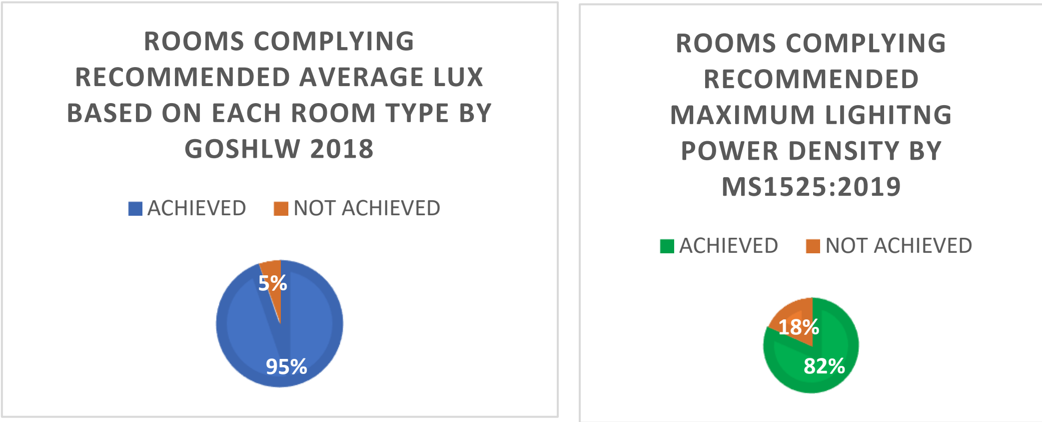
Figure 2 Luminaire list details from DIALux Evo 12.0



(a) (b)

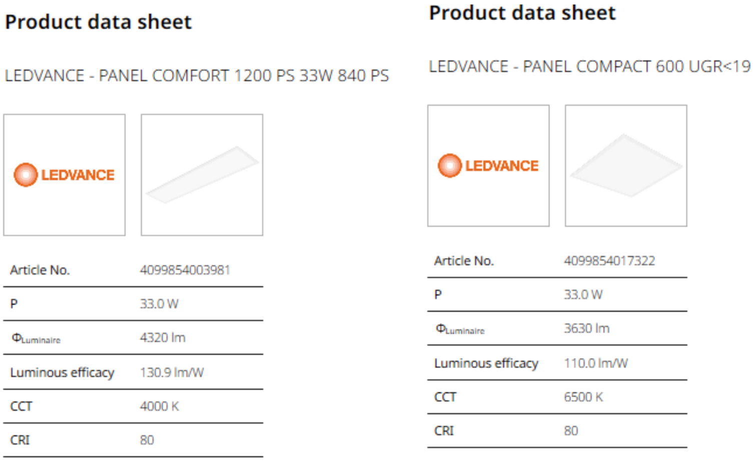
Figure 3 Construction of related rooms and areas in DIALux Evo: (a) First floor (b) Second floor

As can be seen from the luminaire list above, the total power usage of the existing lighting system is **22.5705kW**. The most luminaire used is the RIDI CFL 4by2ft lamp, which is the closest available in the software's catalogue to match the OSRAM L36W865 currently used in FTKM "Green" building, followed by K418 CFL, to accommodate OSRAM 2by2ft lighting. Figure 3 below shows the condition of the current lighting system, which is mostly aligned with the local standards. Retrofitting will optimize the lighting system to achieve the standards in all rooms. Based on the luminaire catalogue provided by DIALux Evo 12.0, the best replacement for RIDI 4by2ft is selected based on size and fitting similarity and luminous efficacy. Figure 4 shows LEDVANCE Panel Comfort 1200, a panel LED type luminaire to replace the 4by2ft CFL lamps and LEDVANCE Panel Comfort 600 to replace OSRAM 2by2ft.



(a) (b)

Fig. 3 Lighting system comparison to standards: (a) Average lux comparison, (b) LPD comparison



(a) (b)

Fig. 4 Data Sheets for LEDVANCE Panel Comfort luminaires: (a) LPC 1200 (b) LPC 600

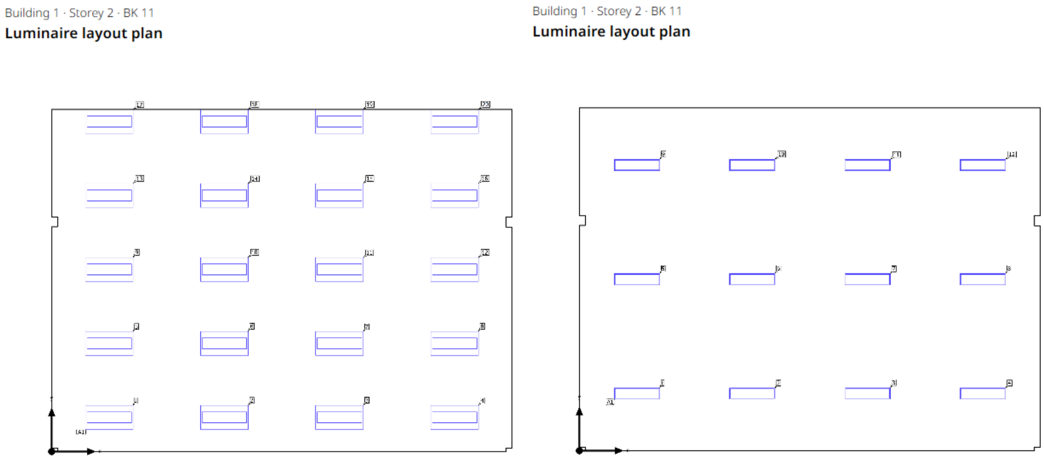
Aside from replacing CFL with LED lamps, the positions and numbers of luminaires are optimized, reducing power consumption while complying to average lux recommendation with the minimum number of luminaires. Energy analysis is compared between existing and retrofitted lighting systems. Figure 5 below shows the luminaire list for retrofitted lighting system. From the list, we can see the number of luminaires were minimized in plenty and the power consumption is significantly reduced, down to **8.4835 kW**.

Φ_{total}	P_{total}	Luminous efficacy
1057731 lm	8483.[illegible] W	124.7 lm/W

pcs.	Manufacturer	Article No.	Article name	P	Φ	Luminous efficacy
184	LEDVANCE	4099854003981	PANEL COMFORT 1200 PS 33W 840 PS	33.0 W	4320 lm	130.9 lm/W
39	LEDVANCE	4099854017322	PANEL COMPACT 600 UGR<19 DALI 33W 865 U19 DALI	33.0 W	3630 lm	110.0 lm/W
3	Petridis	88453302_	ERIS_4_SYM._LED_CHIP_19W_NEUTRAL_MEDIUM	38.0 W	5002 lm	131.6 lm/W
9	Philips		SM136V LED43S/840 OC WIA W20L120	34.5 W	4300 lm	124.6 lm/W
25	Regent	1008.8810 - ECHO210	Recessed downlight Echo 210 28W 2700lm CRI > 90 4000K white	28.0 W	2703 lm	96.5 lm/W

Fig. 5 Luminaire list

Figure 6 shows a sample room, that is BK11, one of the classrooms that was heavily optimized during the simulation. The lighting system for this room before and after retrofitting is shown below. Since the standard average lux recommendation for a classroom in Malaysia based on GOSHLW 2018 is 300 lx, the number of luminaires is reduced from the existing 826 lx to 341 lx. The number of luminaires is reduced from 20 units RIDI 4by2ft to only 12 units LEDVANCE Comfort Panel 1200, hence bringing down the total power from 1440W to 396W.



(a) (b)

Fig. 6 Luminaire layout: (a) Existing (b) Retrofitted

Assuming the building operates from 8.00 AM to 5.00 PM, the building operates 9hrs/day. The total number of days it is operating is taken as the approximate number of working days in Malaysia which can be assumed approximately at 250 days/year. The energy saving then can be calculated. The Malaysian commercial tariff for electricity cost can also be calculated, therefore the building falls into category tariff C1 [7]. The reduction in carbon emission of electrical generation by this lighting system is calculated by using equation 1 below. [8]

$$Carbon\ emission\ per\ year, \frac{kgCO_2}{yr} = Carbon\ intensity * \frac{kWh}{yr}$$

$$Carbon\ intensity\ in\ Malaysia = \frac{600gCO_2}{kWh} = \frac{0.6kgCO_2}{kWh}$$

Equation 1

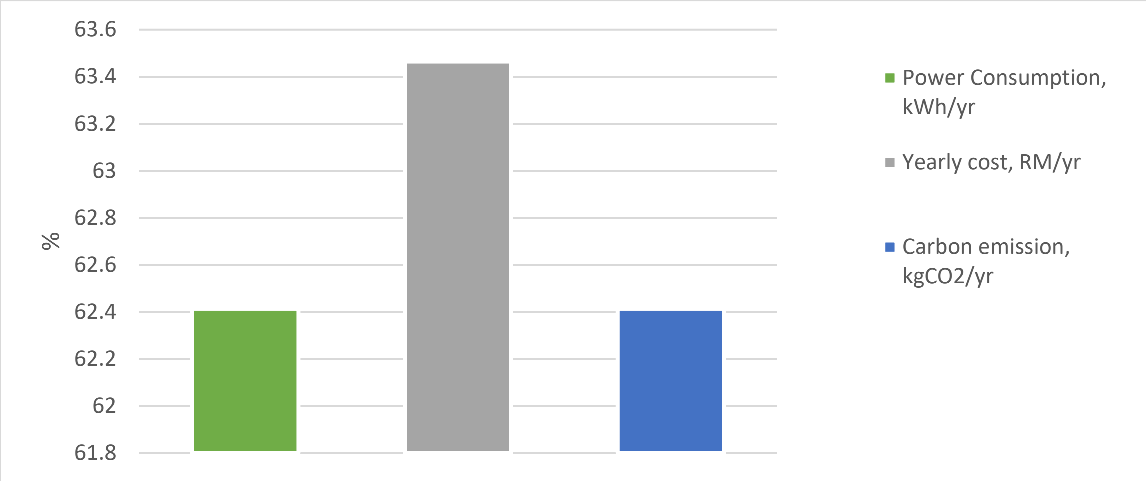


Fig. 6 Percentage reduction of lighting system analysis comparison between existing and retrofitted design.

Conclusion

The results of this investigation demonstrate the successful achievement of the objectives set for retrofitting the lighting system in the FTKM "Green" building. This study highlights the application of DIALux Evo 12.0 as a simulation tool to predict energy savings, ensuring compliance with local policies and lighting standards such as MS1525:2019 and GOSHLW 2018. Key findings include a 62.41% reduction in energy consumption (31,695.75 kWh/year), a 63.46% decrease in electricity costs (approximately RM5,904.24/year), and a notable reduction in carbon emissions (19.018 tCO_2/year). These outcomes underscore the potential of simulation-driven approaches to optimize energy and cost savings, aligning with broader sustainability and carbon reduction goals (Ali et al., 2020; Kamaruddin et al., 2016).

Furthermore, the study demonstrates the role of advanced simulation tools like DIALux Evo in streamlining the design and evaluation process, providing accurate modeling for real-world scenarios (Nurrohman et al., 2021). The methodology serves as a practical framework for similar energy optimization projects, promoting sustainable lighting practices in educational and commercial buildings (Veitch & Galasiu, 2012). However, the investigation encountered limitations, such as challenges in replicating architectural constraints like blinders, which suggest areas for refinement in future research. Future investigations could integrate complementary tools like Building Information Modeling (BIM) to enhance simulation accuracy and account for complex architectural features (Skarżyński & Rutkowska, 2020).

The findings also emphasize the importance of adopting energy-efficient lighting solutions as a key strategy for sustainable building operations. As highlighted by Maines (2021), transitioning to LED systems in educational facilities not only achieves significant energy savings but also enhances visual comfort and learning environments. By providing a robust framework for implementation and evaluation, this study contributes to the growing body of knowledge supporting energy-efficient retrofitting in educational facilities and beyond, advancing global sustainability objectives and improving operational efficiencies.

Recommendations

To further enhance the outcomes of this study and address its limitations, future research should explore the integration of additional simulation tools to complement DIALux Evo's capabilities. Tools that allow for detailed modeling of architectural features, such as blinders or façade systems, could provide a more accurate representation of real-world conditions. Expanding the study to include dynamic lighting simulations that account for varying daylight conditions throughout the year would optimize the balance between artificial and natural lighting, reducing energy consumption further. Lifecycle cost analysis (LCCA) should also be incorporated to assess the long-term economic and environmental benefits of retrofitting, including maintenance and replacement costs.

Moreover, expanding the scope of this study to include occupant feedback on the retrofitted lighting systems would ensure that energy savings do not come at the expense of user comfort, safety, and productivity. Surveys and real-time monitoring of the lighting environment could help evaluate factors such as visual comfort, glare reduction, and task performance under the new lighting system. Scaling this approach to other buildings, including administrative offices and residential halls, would demonstrate the broader applicability of the methodology, contributing to institutional sustainability goals and serving as a replicable model for organizations aiming to achieve energy efficiency in their lighting systems.

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