Journal of Power and Energy Engineering, 2025, 13(8), 101-113
https://www.scirp.org/journal/jpee
ISSN Online: 2327-5901
ISSN Print: 2327-588X

Simulation-Based Assessment of Lighting System Configuration in the Faculty of Electrical Technology and Engineering (FTKE), UteM

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How to cite this paper: Saharuddin, N.Z., Ruslan, M.I.D.M., Kamal, I., Shair, E.F. and Naidu, K. (2025) Simulation-Based Assessment of Lighting System Configuration in the Faculty of Electrical Technology and Engineering (FTKE), UteM. *Journal of Power and Energy Engineering*, **13**, 101-113.
https://doi.org/10.4236/jpee.2025.138007

Received: July 28, 2025
Accepted: August 19, 2025
Published: August 22, 2025

Abstract

Lighting systems play a crucial role in any educational building, influencing not only the aesthetic and functional aspects of spaces but also contributing to energy efficiency and overall system performance. This study investigates the lighting system configuration within the Faculty of Electrical Technology and Engineering (FTKE), focusing on the hallways and main lobbies of Blocks A, B, and C, with particular attention to its efficiency, performance, and compliance with MS1525 standard. The study involves a thorough analysis of the current lighting infrastructure, examining fixture types, configuration and energy consumption. DIALux Evo software was utilized to determine the optimal lighting arrangement that satisfies minimum lux requirements while reducing power consumption. The assessment found that the current lighting infrastructure at FTKE generally fulfills the basic illumination requirements in most cases; however, it also identified significant opportunities for improvement. By reconfiguring the lighting system, energy consumption was significantly lowered, and lighting quality was enhanced. The findings indicate that the proposed configurations successfully reduced annual power consumption while maintaining compliance with the MS1525 standard. The outcomes of this research contribute to ongoing efforts to promote sustainable practices within campus environments and align with Sustainable Development Goal 7 (Affordable and Clean Energy) by encouraging the responsible and efficient use of lighting systems.

Keywords

Lighting System Configuration, Energy Efficiency, DIALux Evo, Energy

Consumption, MS1525 Standard

1. Introduction

Lighting in educational buildings is essential for creating an effective and supportive learning environment. In educational buildings, such as classrooms, laboratories, libraries, and administrative offices, effective lighting is essential to create conducive learning and working conditions while optimizing energy use and reducing operational costs. A significant amount of energy in educational facilities is used for interior lighting. With rising energy costs, efforts to reduce this usage focus on improving lighting control systems to prevent energy waste during daylight and vacant hours [1].

Lighting assessment is essential as it ensures that spaces are illuminated effectively, enhancing both functionality and safety. Proper lighting improves visual comfort, reduces eye strain, and can significantly impact productivity and mood. Therefore, this research aims to improve the lighting system configuration at the Faculty of Electrical Technology and Engineering (FTKE) to enhance energy efficiency and optimize costs. The lighting system configuration in the main building of a faculty, including administration areas, corridors, and hallways should be improved, as these are heavily used spaces [2]. This study analyzes the visual environment in hallways and the lobby using DIALux Evo software according to MS1525 standards [3], proposing the best configuration that achieves the desired lux level with low power consumption [4]. The current lighting system in these areas is not adequately analyzed to meet the lighting standards outlined in MS1525. Using DIALux Evo software, the research targeted to optimize lighting configuration to meet standard MS1525 and enhance energy efficiency and sustainability.

By analyzing the current lighting configuration, identifying inefficiencies, and proposing better solutions, the research supports the institution's commitment to sustainable development and technical innovation [5]. The study offers practical recommendations for significant energy savings and increased illumination quality [6]. It involves assessing the power consumption of the existing lighting system and comparing it with potential new configurations. Recommendations for changes or upgrades are made to improve lighting quality, user satisfaction, and energy savings [7]. It also includes minimizing energy consumption and evaluating the effectiveness of the various lighting configurations in the FTKE main building [8].

Therefore, this research focuses on a comprehensive evaluation of the lighting configurations in the hallways and main lobby of Block A, Block B, and Block C at FTKE. The assessment will consider both energy consumption and lighting levels [9]. The study will propose the most effective lighting system configuration designed to minimize electricity consumption in accordance with MS1525 [10]. DIALux Evo software will be used to simulate and analyze the configuration.

2. Proposed Method

This research was carried out to propose an improved lighting system configuration for the hallways and main lobbies of Blocks A, B, and C at Faculty of Electrical Technology and Engineering (FTKE), with the aim of enhancing functionality, safety, and comfort while maximizing energy efficiency and minimizing costs. A good lighting configuration is crucial because it directly impacts functionality, safety, power consumption and well-being especially in educational building [11].

The flowchart in **Figure 1** outlines a structured process for assessing and enhancing the lighting configuration in the selected areas (hallways and main lobbies of Blocks A, B, and C). The process begins with an analysis of the physical layout and identification of the existing lighting system configuration [12]. A new lighting system configuration is then developed and simulated using DIALux Evo software that compliance with the minimum average lux levels specified in the MS1525 standard [13]. If the simulation results do not meet the required lux levels, the process is repeated until the desired lux level is achieved [14]. Once compliance is achieved, a comparative analysis is conducted between the existing and proposed lighting systems, focusing on both technical performance and economic viability [15]. The final output is a proposed lighting configuration that complies with the MS1525 standard, ensures sufficient illumination, and optimizes both energy use and operational costs [16].

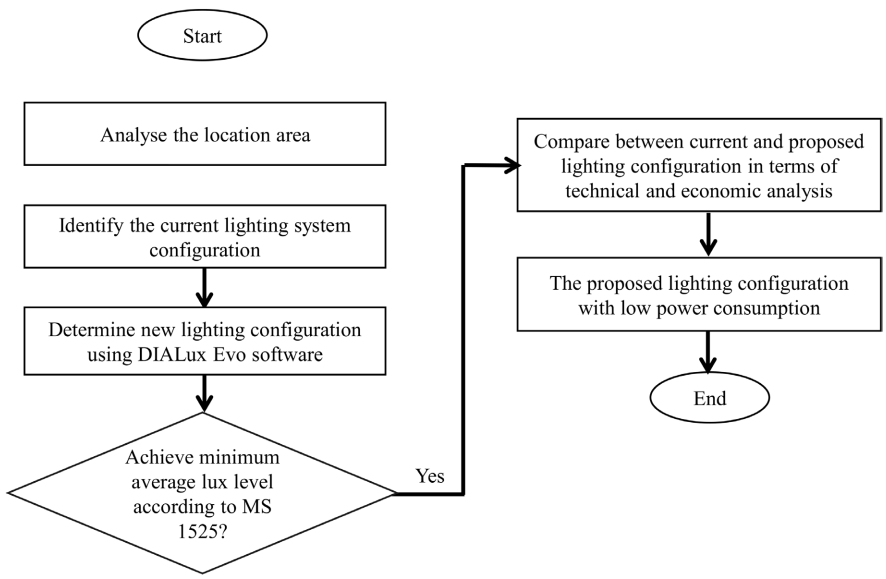

Figure 1. Flowchart of the proposed lighting assessment.

3. Methodology

This research simulates the lighting configuration for the hallway and main lobby of FTKE's main building, aiming to identify potential energy savings and efficiency improvements [17]. The study considers various aspects to propose an optimal lighting setup and includes a research technique diagram [18]. Different lighting levels are required depending on room usage, with a minimum of 100 lux specified for hallways and lobbies according to the MS1525 standard [19].

3.1. Simulation Using DIALux Evo Software

Simulations of the hallways on Levels 1 to 4 in Blocks A and B, as well as the main lobby on Level 1 of Block C, were carried out based on the official FTKE building plan. The analysis considered key lighting characteristics, including the color rendering index (CRI) and color temperature of the existing fixtures [20]. For each space, the most suitable lighting configuration was recommended to ensure compliance with the minimum illuminance levels specified in the MS1525 standard [21]. Details of the initial lighting systems for the hallways and lecture halls in Blocks A, B, and C are presented in **Table 1**.

Table 1. Specification of lighting fixture.

Luminaire	MAS LEDtube 600 mm HO 8W830 T8
Lighting Technology	LED
Luminous Flux	1000 lm
Correlated Color Temperature	3000 K
Color rendering index (CRI)	83
Power Consumption	8 W
Product Length	600 mm
Bulb Shape	T8

Once the lighting fixture is selected, the DIALux Evo software will be used to simulate the number of fixtures required to meet both the minimum recommended lux levels and the maximum allowable lighting power as specified in the MS1525 standard [22]. The simulation will be based on the average illuminance values calculated by the software. Key parameters considered in the analysis include the achieved average lux level (lx), illuminance uniformity, total power (W), total annual energy consumption (kWh/year), and overall energy efficiency [23]. Once all parameters are met, the best lighting configurations with lower power consumption for the hallway are simulated and proposed [24]. Adhering to these guidelines is crucial to prevent eye strain, headaches, and stress. Moreover, proper lighting promotes better health, which in turn boosts productivity and satisfaction [25]. In addition to the amount of electrical current used, the average light level achieved at the work plane also needs to be considered. MS 1525 specified the work plane lux level for hallway and lobby must be at least 100 lux. The annual operating hours and total annual power consumption are also calculated. For this study, the operating hours are assumed to be nine hours per day, five days per week, over fifty-two weeks per year [21].

3.2. Economic Analysis

According to the simulation results, the new improved lighting configuration system used the least amount of power while meeting all technical requirements. To support its economic viability, an economic analysis is conducted using the TNB tariff for medium voltage commercial buildings (Tariff C1), as shown in **Table 2**. The total annual power usage is multiplied by 36.5 sen per kWh to calculate the total cost in Ringgit Malaysia (RM) [26].

Table 2. TNB Tariff C1–Medium voltage general commercial tariff.

Tariff C1-Medium Voltage General Commercial Tariff	
For each kilowatt of maximum demand per month	30.3 RM/kW
For all kWh	36.5 sen/kWh
The minimum monthly charge is RM600	

The annual operating hours, assuming nine hours per day, five days per week, and fifty-two weeks per year, are calculated using Equation (1). The total annual power consumption is determined using Equation (2) [27].

$$\begin{aligned} &\text{Annual operating hours}(\text{hours}) \\ &= \text{Daily operating hours} \times \text{Weekly operating days} \times 52 \text{ weeks} \end{aligned} \tag{1}$$

$$\begin{aligned} &\text{Total annual power consumption}(\text{W} \cdot \text{h}) \\ &= \text{Total power consumption}(\text{W}) \times \text{Annual operating hours}(\text{hours}) \end{aligned} \tag{2}$$

4. Result and Discussion

The research involves simulating and comparing the average lux levels and energy consumption of the existing and improved lighting configurations in the main building of FTKE, with a specific focus on the hallways of Blocks A and B, as well as the main lobby of Block C. According to MS 1525, the minimum required lux levels are 100 lux for both hallways and the lobby. The goal is to propose the most efficient lighting configuration with the lowest energy consumption, based on a comparison of the existing and proposed configuration. In this simulation, the spacing between light fixtures, the quantity of fixtures employed, and the configuration of fixtures for each lighting system design have been varied. The area focused on the simulation work of the lighting system configuration are shown in **Table 3**.

Table 3. Simulation area for lighting configuration.

Location	**Block A (Area)**	**Block B (Area)**	**Block C (Area)**
Level 1	Hallway (65.25 m^2)	Hallway (66.44 m^2)	Lobby (204.82 m^2)
Level 2	Hallway (63.64 m^2)	Hallway (67.91 m^2)	-
Level 3	Hallway (76.43 m^2)	Hallway (77.77 m^2)	-
Level 4	Hallway (77.52 m^2)	Hallway (78.10 m^2)	-

4.1. Case Study 1: Block A

The areas covered in Block A encompass the hallways of all four levels. To meet the required lux levels as per the MS1525 standard while minimizing power consumption, these areas were designed using DIALux Evo software. Figures 2-5 presents the simulation results for current (before) and the proposed (after) lighting configurations for the hallways (levels 1 - 4), while Table 4 presents the technical analysis of these configurations.

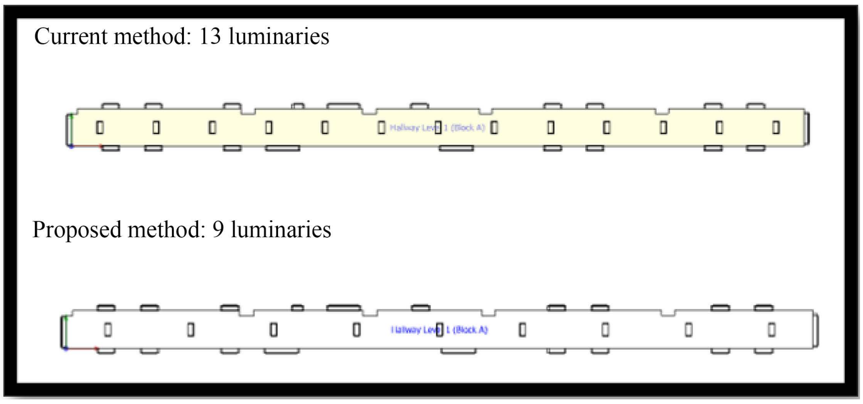

Figure 2. Hallway block A (Level 1).

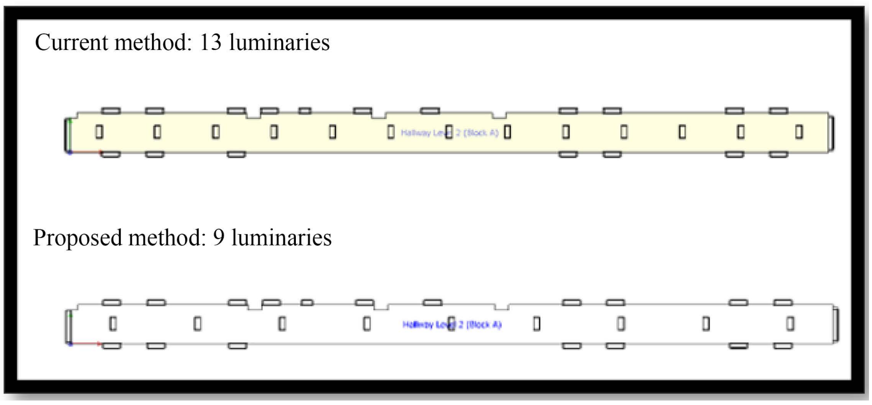

Figure 3. Hallway block A (Level 2).

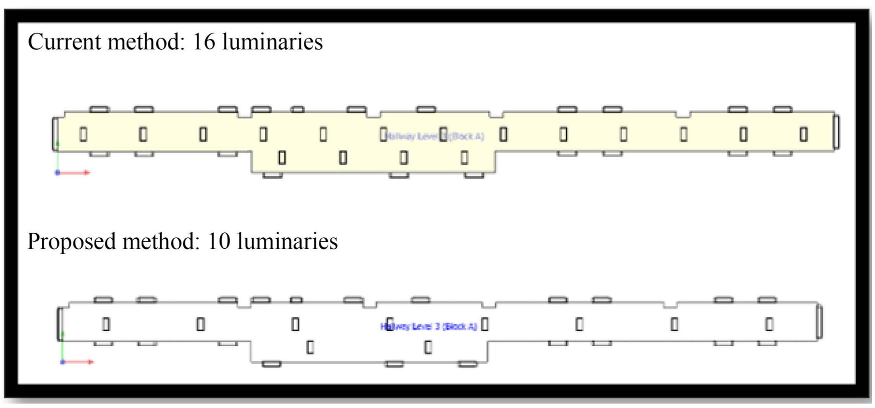

Figure 4. Hallway block A (Level 3).

Table 4. Technical data for block A.

Location Block A	Local luminaries		Average lux achieve (lx)		Total power (W)		Total annual power consumption (kWh/year)	
	Current technique	Proposed technique	Current technique	Proposed technique	Current technique	Proposed technique	Current technique	Proposed technique
Hallway Level 1	13	9	149	104	208	144	400	277
Hallway Level 2	13	9	147	103	208	144	400	277
Hallway Level 3	16	10	178	106	256	160	524	308
Hallway Level 4	16	10	174	104	256	160	523	308

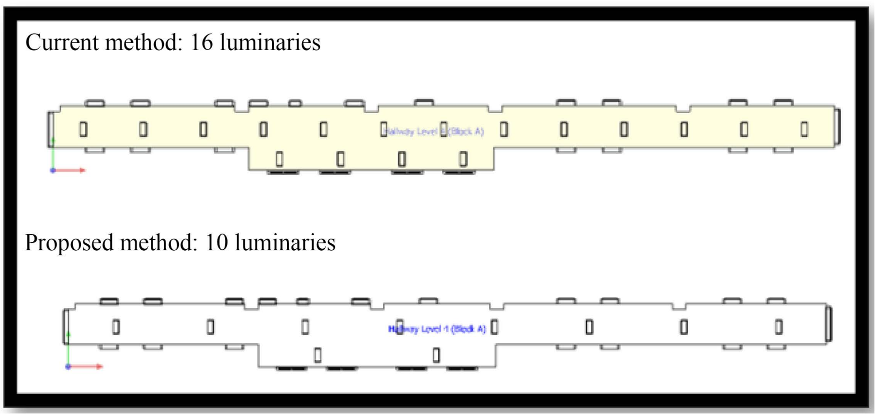

Figure 5. Hallway block A (Level 4).

Referring to **Table 4**, the proposed lighting configurations for hallway levels 1 and 2 reduced to 9 luminaires per level, compared to the current configuration, which employs 13 luminaires per level. It is shown that the proposed lighting configurations use a fewer number of luminaries while meeting the MS1525 standard of 100 lux for these areas. This change reduced the average lux for hallway level 1 from 149 lx to 104 lx and for level 2 from 147 lx to 103 lx, reducing the total power usage from 208 W to 144 W and annual consumption from 400 kWh/year to 277 kWh/year. On the other hand, for the hallways on levels 3 and 4, the number of luminaires was reduced from 16 to 10 each. These reductions caused the average lux levels to drop from 178 lx to 106 lx for level 3 and from 174 lx to 104 lx for level 4. As a result, the total power usage was reduced from 256 W to 160 W for both level 3 and level 4. The annual energy consumption further decreased from 524 kWh/year to 308 kWh/year for hallway level 3 and from 523 kWh/year to 308 kWh/year for hallway level 4.

4.2. Case Study: Block B

Case study 2 focuses on the hallways across all four levels. The lighting design for these hallways was designed using DIALux Evo software to meet the required lux levels as per the MS1525 standard while minimizing power consumption. **Figures 6-9** illustrate the simulation results for the existing (before) and proposed (after) lighting configurations for Block B, covering levels 1 to 4, while Table 5 presents the technical analysis of these configurations.

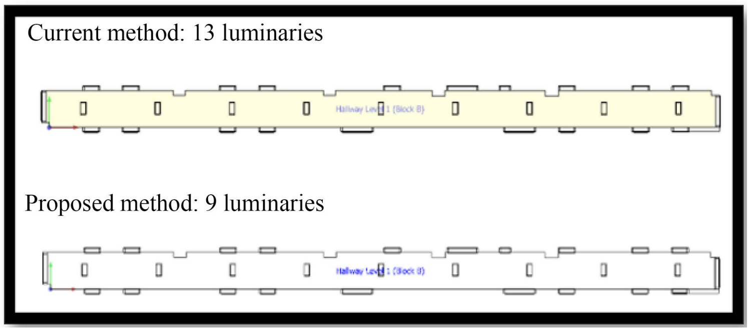

Figure 6. Hallway block B (Level 1).

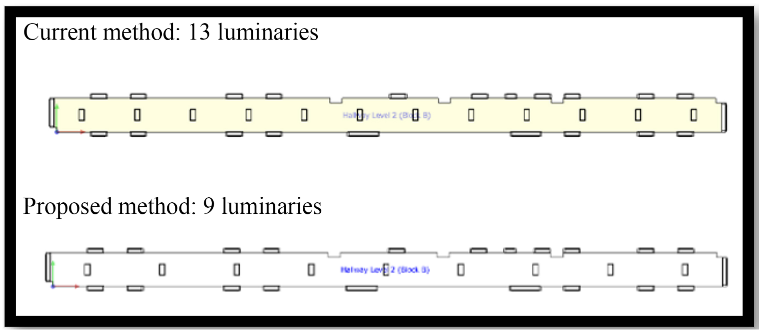

Figure 7. Hallway block B (Level 2).

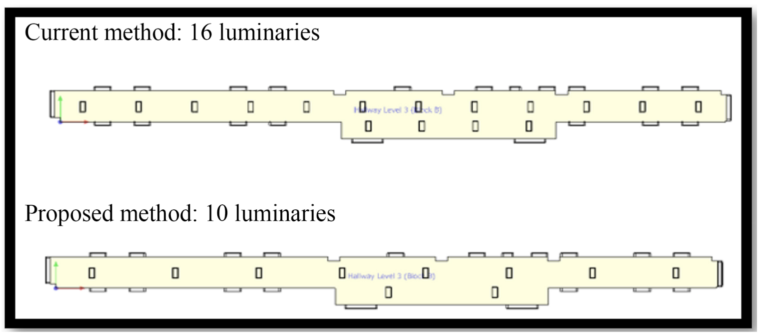

Figure 8. Hallway block B (Level 3).

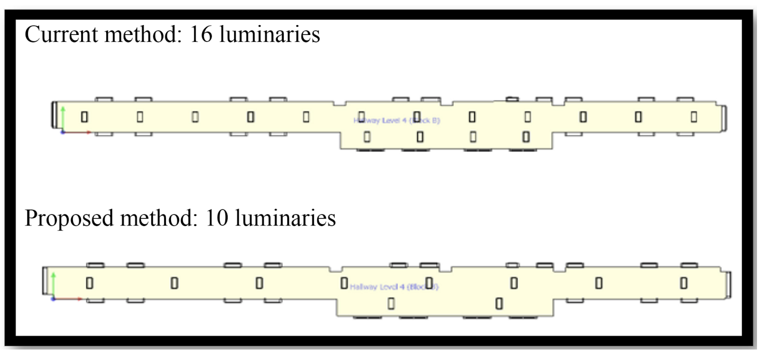

Figure 9. Hallway block B (Level 4).

Table 5. Technical data for Block B.

Location Block B	Local luminaries		Average lux achieve (lx)		Total power (W)		Total annual power consumption (kWh/year)	
	Current technique	Proposed technique	Current technique	Proposed technique	Current technique	Proposed technique	Current technique	Proposed technique
Hallway Level 1	12	9	179	106	192	144	370	277
Hallway Level 2	12	9	178	106	192	144	370	277
Hallway Level 3	16	10	173	109	256	160	493	308
Hallway Level 4	16	10	169	107	256	160	493	308

According to Table 5, the proposed lighting configurations for the hallways on levels 1 and 2 reduced the number of luminaires from 12 to 9 per level. Despite using fewer luminaires, the proposed design still meets the MS1525 standard of 100 lux for these areas. This adjustment lowered the average lux levels from 179 lx to 106 lx on level 1 and from 178 lx to 106 lx on level 2, resulting in a reduction in total power usage from 192 W to 144 W and a decrease in annual energy consumption from 370 kWh/year to 277 kWh/year. Similarly, for the hallways on levels 3 and 4, the number of luminaires was reduced from 16 to 10 per level. This led to a decrease in average lux levels from 173 lx to 109 lx on level 3 and from 169 lx to 107 lx on level 4. Consequently, total power usage dropped from 256 W to 160 W, and annual energy consumption was reduced from 493 kWh/year to 308 kWh/year per hallway.

4.3. Case Study 3: Block C

The Block C covered the main lobby of FTKE only. Figure 10 provides a comparison of the lighting setups of the new and existing lighting configuration systems in order to achieve the minimum lux level according to the standard while minimising power consumption. Table 6 provides a technical comparison between the new and existing lighting systems.

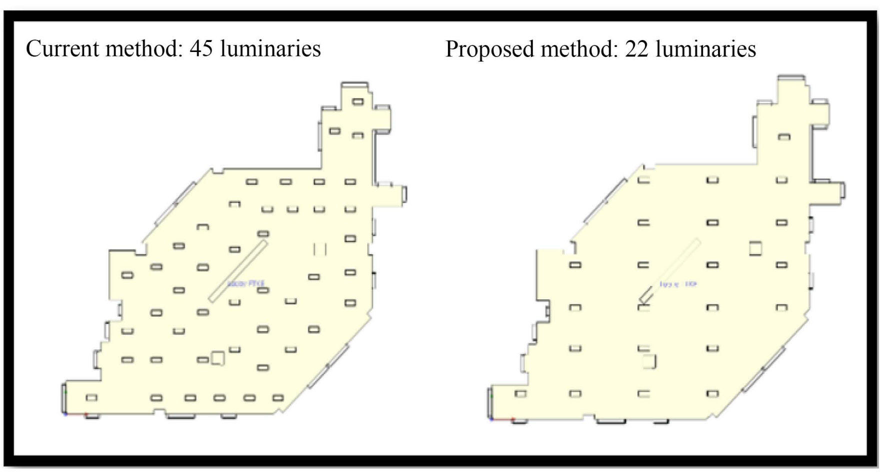

Figure 10. Lobby block C (Level 1).

Table 6. Technical data for Block C.

Location Block C	Local luminaries		Average lux achieve (lx)		Total power (W)		Total annual power consumption (kWh/year)	
	Current technique	Proposed technique	Current technique	Proposed technique	Current technique	Proposed technique	Current technique	Proposed technique
Lobby	45	22	235	115	720	352	1782	678

The main lobby of FTKE in block C originally had 45 luminaires, but after reconfiguration to comply with the MS1525 standard of 100 lux, the number was reduced to 22. This adjustment led to a significant decrease in the average lux level, dropping from 235 lx to 115 lx which in turn reduced the total power usage from 720 W to 352 W, and annual power consumption from 1782 kWh/year to 678 kWh/year

4.4. Economic Analysis

Following the simulation results, the total annual power consumption was compared to assessing the electricity costs between the current technique and the proposed technique of the lighting system. Table 7 shows the total electricity bill saving in Ringgit Malaysia (RM).

Table 7. Economic data.

Location		Annual Energy Consumption (kWh/year)	
		Current technique	Proposed technique
Block A	Hallway Level 1	400	277
	Hallway Level 2	400	277
	Hallway Level 3	524	308
	Hallway Level 4	523	308
Block B	Hallway Level 1	370	277
	Hallway Level 2	370	277
	Hallway Level 3	493	308
	Hallway Level 4	493	308
Block C	Lobby	1782	678
Total Annual Energy Consumption (kWh/year)		5355	3018
Annual Electricity Bill (RM)		1954.58	1101.57
Total electricity bill saving (RM)		853.01	

Table 7 provides a detailed comparison of the annual energy consumption between the current configuration and the proposed configuration across various locations within blocks A, B, and C at FTKE. In Block A, the energy consumption for all four hallway levels decreased from 400 kWh/year to 277 kWh/year for Levels 1 and 2, 524 kWh/year to 308 kWh/year for Level 3, and 523 kWh/year to 308 kWh/year for Level 4. Similarly, in Block B, the energy consumption for all hallway levels dropped from 370 kWh/year to 277 kWh/year for Levels 1 and 2 and 493 kWh/year to 308 kWh/year for Levels 3 and 4, respectively. The most significant reduction occurred in Block C's lobby, where energy consumption decreased from 1782 kWh/year to 678 kWh/year. Overall, the total annual energy consumption was reduced from 5355 kWh/year to 3018 kWh/year, leading to a decrease in the annual electricity bill from RM 1954.58 to RM 1101.57. This resulted in a total electricity bill saving of RM 853.01 per year.

5. Conclusion

In this research, the improved lighting configurations for the hallways and main lobby of FTKE were proposed by reconfiguring the existing system using DIALux Evo software, in accordance with the MS1525 standards. The primary objective of the assessment, which was to reduce power consumption at FTKE, was successfully achieved. The implementation of the optimized lighting design has resulted in a more efficient system that significantly reduces energy usage while still meeting all technical and regulatory requirements. This outcome demonstrates the effectiveness of the proposed lighting strategy in enhancing system performance and achieving substantial cost savings.

Acknowledgements

The authors wish to express their gratitude to the Universiti Teknikal Malaysia Melaka (UTeM), Fakulti Teknologi dan Kejuruteraan Elektrik (FTKE), Centre of Robotic and Industrial Automation (CERIA) and Centre of Research and Innovation Management (CRIM), for funding this study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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