Asian Journal of Applied Science and Technology (AJAST)
Volume 9, Issue 2, Pages 136-147, April-June 2025

Illumination Infrastructure of the Electrical Engineering Building in Dhvsu Main Campus toward Institutional Policy on Lighting Management

Ed Amiele D. Guevarra[1], John Aron Michael L. Fernandez[2], Marty G. Alfonso[3] & Armie C. Tolentino[4*]

[1-4]Department of Electrical Engineering, Don Honorio Ventura State University, Philippines.
Corresponding Author (Armie C. Tolentino) Email: actolentino@dhvsu.edu.ph[*]

DOI: https://doi.org/10.38177/ajast.2025.9213

Article Received: 09 April 2025 *Article Accepted: 16 June 2025* *Article Published: 19 June 2025*

ABSTRACT

The illuminance of a building, particularly in a classroom, has to obtain a lumen of 300 minimum and 750 maximum, based on the standards set by the Department of Energy. This plays a crucial role to a student or instructor in terms of how much lumens a classroom needs. Certain facilities tend to disregard the so-called “Illumination Standards” that users need to execute the work. This study focuses on assessing the current lighting fixtures and illumination levels of the Electrical Engineering Building of Don Honorio Ventura State University (DHVSU Bacolor Pampanga Philippines 2001) in compliance with the Department of Energy’s Illumination Standard of a classroom. The researchers discovered that the said building has been using an 18-watt non-LED with a luminous flux of 1800. It was figured out that the current lighting fixtures were tested 100 up to 250 lumens. As a result, the study recommended using a 36W with a luminous flux of 3600. This paper also proposed a lighting management policy including selective switching, upgrading to newer lighting fixtures, and energy-efficient lighting, following the standards from the abovementioned department.

Keywords: Illuminance; Lighting Fixtures; Classroom; Lumens; Lighting Management Policy; Luminous Flux; Energy-Efficient Lighting.

1. Introduction

Lighting appears to have the most influence on building occupants among all the factors that may be involved. The effects range from physical and physiological to psychological. For a long time, it has already been the concern that lighting design should be appropriate to meet the needs of the building occupants, particularly when it comes to visual task performance. Recently, the link between lighting, performance, and health has made the illuminance of building interiors one of the most prominent considerations in architectural design [1,3].

On the other hand, sufficient light and favorable lighting conditions are far more important in this regard [1]. Since educational institutions often need lighting over areas of property, they have wide lighting requirements for indoors as well as outdoors. With their ongoing expansion and campus upgrades, colleges and universities in particular should be aware of complying with the illuminance level [2]. The projects that involve lighting in these classroom areas must change to reflect the activities taking place within. Laboratories, art studios, and classrooms are all covered by the illuminance standard. For example, the lighting in an art studio and a computer room are not the same. The lighting in classrooms, which includes areas used for tutoring, hands-on activities, and teaching must be 300 lumens up to 750 lumens. In addition, good lighting improves the learning environment for teachers and students [2]. In terms of lighting design for educational settings, lumens, and brightness levels are more than just lighting; they capture the mood of creating ideal conditions for effective learning [4,5].

A greater priority is being placed on building a comfortable and proper lighting environment that promotes human health and well-being as a result of the desire to improve living standards. Understanding how environmental lighting regulation affects human behavior and physiological responses is important [6]. Lighting is one of the parts of the work environment that can impact a person's performance. These include results that may lead to health damage, reduced ability to accomplish a task, and poor attitude towards work [7].

Fluorescent lighting has always been the go-to option for schools looking for high illumination and energy efficiency. The term "full lights," which resemble daylight, is a recent development in this technology. The efficiency, durability, and full, smooth, uninterrupted spectrum of LEDs (light-emitting diodes) have brought them to the top of the list in recent times. Research has indicated that the integration of LED lighting significantly enhances positive attitudes and actions in both the workplace and classrooms [11]. Studies have shown that exposure to natural light can improve mood, energy levels, and productivity. LED lighting can provide a similar effect, creating a brighter, more vibrant environment that can enhance learning and concentration [12]. Additional energy savings are achieved by connecting LED lights to a classroom. It is possible to save an additional 30 percent in addition to the 40–50 percent that can be saved by converting to LED technology [13].

In addition to assessing the current lighting, this study also helps the researchers determine whether old or upgraded lighting fixtures, wiring systems, and switches are needed. Luminaires and reflectors must be utilized to help in the improvement of illumination. An illuminance level of at least 300 lumens and up to 750 lumens is required for lighting working interiors, particularly in classrooms, to create an institutional policy for energy saving [8,9].

The classrooms in the Electrical Engineering Building have lamps arranged both vertically and horizontally for lighting placement. Other rooms utilize lamps such as fluorescents and bulbs. It has laboratories, offices, and classrooms to operate. In addition to being relevant to illumination standards, the evaluation of its lighting infrastructure and fixtures fits in with the institution's goals. Every classroom in the said building measures 10.5 by 6.85 meters, with a height of 2.7 meters at the student desk; each of these has six fluorescent tubes with the specification of 18-watt and 1800 luminous flux.

1.1. Study Objectives

The objectives of this study are as follows:

(1) To assess the current illumination infrastructure of the Electrical Engineering Building in Don Honorio Ventura State University-Main Campus;

(2) To formulate recommendations and institutional policy to comply with the illumination standard and energy saving of each classroom.

2. Methods

The lighting assessment requires several methods in evaluating the effectiveness, quality, and efficiency of lighting in different settings such as classrooms, laboratories, general offices, and conference rooms. It offers an initial visual inspection by subjective observation to identify issues such as glare, shadowing, and uneven illumination. The amount of light level is measured through a lux meter. This is suitable for the recommended standard of 300 minimum to 750 maximum level of lumens required in the classroom and implements a lighting program management to lower energy consumption. The room index method is used in computing the floor area of room 103 of the Electrical Engineering Building in DHVSU Bacolor Pampanga Philippines 2001.

The lumen method is a widely used technique for calculating the illuminance levels in space by considering the total lumens emitted by the light sources and the room's dimensions. The left, right, and mid are indications of where the tests are conducted to measure the lumens enabling for the designers to ensure that there is enough lighting for various applications. This ensures compliance with the Department of Energy standards, as well as regulatory requirements for lighting design, energy efficiency, and safety. In line, the researchers came up with six scenarios in the study to unravel which is more effective in terms of illumination, lighting efficacy, and lighting power density, while considering energy-saving potential. Lastly, the study also proposed recommendations on lighting management policy for the Electrical Engineering Building of DHVSU Bacolor Pampanga Philippines 2001.

2.1. Methodological Framework

The methodological framework starts with a thorough visual inspection to identify all of the classroom's current lighting fixtures and record their types, locations, and states. Next, exact floor measurements are taken to calculate the total area that needs lighting. Next, key locations in the classroom are marked with strategic placements to ensure a representative sampling of the entire area to measure lux.

Using the appropriate equipment, lux measurements are orderly taken at these designated locations. A thorough evaluation is carried out after collecting the data, wherein the acquired lux measurements are compared to established illumination standards that have been set by the appropriate authority. This analysis led to the design of a remodeling plan for the lighting system that included changing the types of lamps, arrangement, or numbers of lamps to comply with lighting standards.

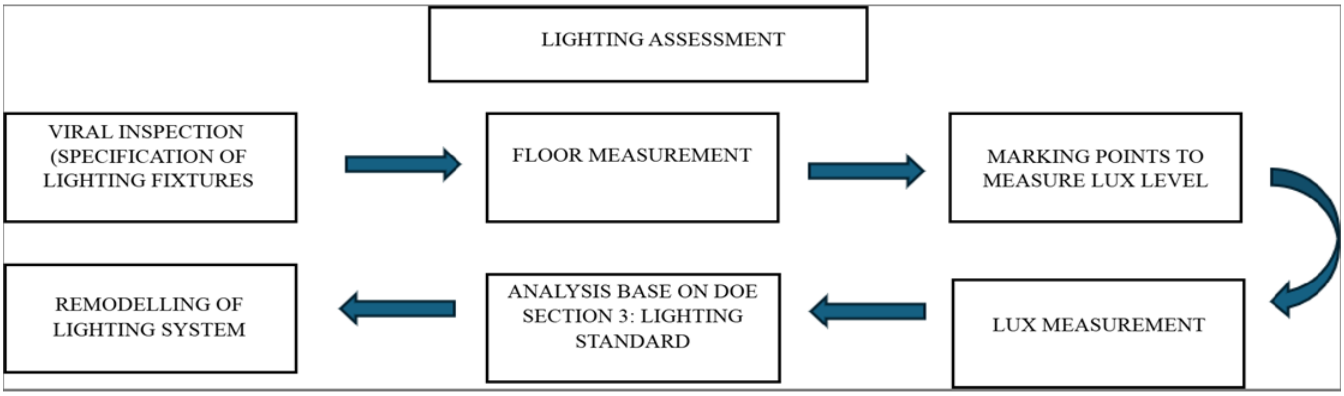

Figure 1. Methodological Framework

This can be considered an achievable plan for Energy Lighting Management; energy-efficient lighting fixtures must be used in the lighting design. The lighting system should be designed to use the least amount of energy, while still offering a pleasing, effective, and adaptable environment for its intended purpose. Selective switching choices should be provided so that lighting levels can be adapted to meet changing needs, and individual or a specific group of fixtures can be turned off when not in use. The lighting system needs to be planned to accommodate expected activity. To determine the lighting needs throughout the space, the task will be analyzed in terms of difficulty, duration, importance, and location. It is important to keep in mind that while lower illumination levels can affect visual effectiveness, higher illumination levels are likely to waste energy. This is where the recommended level of illumination is presented [9].

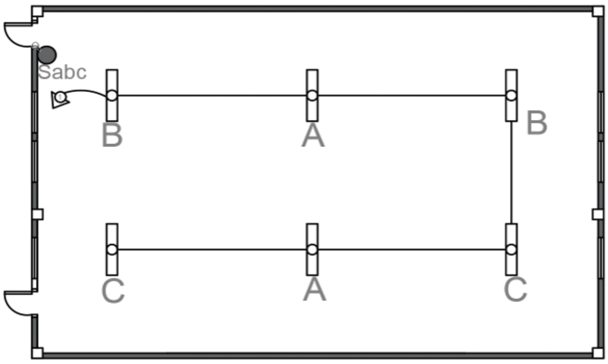

Figure 2. Proposed Lighting Layout

As shown in Figure 2, the researchers proposed a Lighting Layout in the B103 Electrical Engineering Building using a recommended 18W LED and 36W LED for selective switching for energy-saving potential, while still achieving the illumination standard and lessening the operating cost. Considering the natural light, use only switch (A) to illuminate the whole classroom.

2.1.1. Computation for Lighting Design

The ratio that shows the height of the area in comparison to its length and width is referred to as the "room index." The calculation below can be used to determine the value that the classroom provides [22]:

$Room\ index$ = L*W/ H(L+W) (1)

The working plane height, width, and length are multiplied by this formula. By employing the room index method, designers may ensure that their design properly represents the structural dimensions of the space. This makes it possible for more efficient study production and ensures that the exact measurement provides statistically valid results.

The recessed lighting placement is a method where the lighting fixture is placed in the ceiling to illuminate the specific surfaces or areas inside the rooms [24]. The formula used is:

D= L/N*2 (2)

where N is the number of lights in the row, D is the distance from the first wall, and L is the length of the room in feet. By utilizing this method, designers can make sure that the first light in a row is positioned correctly to provide balanced illumination in the area.

The utilization factor is important in lighting design because it shows how well a lighting fixture distributes light over a space. This indication is presented by (uf) and derived formally as an equation [25]:

$$uf = \frac{Total\ lumens\ reaching\ the\ working\ plane}{Total\ lumens\ emitting\ from\ source} \qquad (3)$$

This is determined by dividing the amount of light that exits the light source by the amount of light that enters the working plane. The use of utilization factor is a useful tool for determining how effectively a light fixture uses the lumens it produces to illuminate a specific area. A higher utilization factor indicates a more effective division of light, providing excellent lighting conditions over the area.

The lumen method is an important approach in lighting design that guarantees proper illuminance levels in a specific area. Equation [10] describes this method, which determines the number of luminaires required to obtain the required levels of lighting. There are multiple crucial parameters in the formula:

N= E*A/F*UF*MF (4)

E is the average level of illumination required on the work plane; A is the measured work plane of the area; F is the given luminous flux of each lamp; UF is the Utilization Factor, which considers how good the luminaires direct light to the work plane is; MF is the Maintenance Factor, which describes the situation of the fixture dirt accumulation over time and lamp depreciation. By utilizing this method, lighting designers can recognize the exact number and type of luminaires needed to provide the required lighting level, which is between 300 minimum and 750 lumens maximum [9]. The luminaires used in the theoretical method are 18watts non-LED fluorescent light with 1800 luminous flux, 18watts LED fluorescent light with 2100 luminous flux, 20watts LED fluorescent light with 2200 luminous flux, 28watts LED fluorescent light with 2700 luminous flux and lastly, 36watts LED fluorescent light with 3600 luminous flux. This type of fluorescent light was used to identify which are suitable for achieving the required level of lux in the classroom using a minimal number of fluorescent lights.

Lighting efficacy is an essential method in assessing a lighting system's energy efficiency and performance since it measures the system's capacity to transform electrical power into visible light. The lighting efficacy is measured in lumens per watt (lm/W), and is calculated using the equation [27]:

Efficacy (lm/W)= Luminous Flux (Lumens)/Power Consumption (watts) (5)

where the luminous flux that is measured in lumens is divided by the power used by the light source, which is expressed in watts. Lumen flux is the perceived power of visible light emitted by the source; power consumption is the quantity of electrical energy used to create the light. A higher lighting efficacy rating, indicates a more efficient conversion of electrical energy into visible light, demonstrating improved energy efficiency and lighting system performance.

One important method for assessing the energy efficiency of building lighting fixtures is Lighting Power Density (LPD). This metric was determined by applying the equation [28].

LPD= Total Power of Lighting/Area of Space (6)

The formula is that the total power consumption (P, expressed in watts) of all the lighting fixtures is divided by the area of the given space (A, expressed in square feet or square meters). LPD dictates how energy-efficient lighting installations are in improving lighting systems to reduce energy use while maintaining required illumination levels.

2.1.2. Computational Method for Lighting System and Energy Savings

The method for calculating the energy consumption per month is found in equation [19]. This gives a methodical way to calculate how much energy is used in the lighting system. Kilowatt-hours (kWh), a common unit used in utility billing, is the result of this calculation, which determines the energy use in a specific kind of building or structure. This is computed using the formula below:

kWh = Wh/1000 (7)

This method shows how to calculate the energy consumption per month or year in kWh. This is by multiplying the electrical system power consumption in Watts (W) by the number of hours it operates in Time (T) and dividing the data by 1000. The improvement of energy consumption is possible through this method. This gives a piece of useful information about the energy use of lighting systems and how to calculate the monthly or yearly expenses of the said building or area.

2.2. Testing Analysis

To determine which alternative would be effective for illumination, a visual inspection was conducted, and it was found that the base case of the Electrical Engineering Building Room 103 contains 6 fluorescent tubes while other tubes are defective, outdated, and dusty. They are also 18W non-LED arranged horizontally and vertically.

To obtain the information required for the situation, the researchers created six cases and then compared them to determine which was better. They achieved this by considering the wattage, luminous flux, room fittings, classroom measurement, horizontal and vertical placement of the lamp, and lighting efficacy of each LED fluorescent light.

Regarding the capability of each fluorescent light to produce lumens, the horizontal and vertical placement, the hanging position, and with and without reflectors, these factors are conducted in every scenario in order to obtain the desired lumens of the classroom. The researchers examined and evaluated each of the six (6) cases they created, assessing each one's lumens to see if the desired lumens were reached. Case 1 is the base case of the scenario, with old lighting fixtures and outdated fluorescent lamps. Cases 2, 3, and 4 are the cases where the fluorescent light is 18watts (with and without reflectors), and the position of each fluorescent lamp is either horizontally or vertically arranged; however, in case 3, the fluorescent lamp is hanging from the ceiling. Case 5 has LED fluorescent lights with a horizontal arrangement. Lastly, Case 6 uses an 18-watt LED fluorescent light with a higher lighting efficacy compared to the fluorescent light used in Cases 1, 2, 3, and 4.

* Case 1 is the based case of this model, using an 18-watt fluorescent light non-LED that produces 1800 lumens, and the fluorescent position of this model is horizontal and vertical for each light.

* Cases 2, 3, and 4 use an 18-watt fluorescent light non-LED with a luminaire reflector positioned horizontally and vertically for each light. Scenario 2 uses only a reflector, while Scenario 3 uses a hanging metal bar. Lastly, Scenario 4 uses both a luminaire reflector and a metal hanging bar.

* Case 5 uses 36-watt LED fluorescent lights with higher efficacy that can reach a minimum to medium lux level that uses only six fluorescent lights without the help of a reflector and hanging metal.

* Case 6 uses 18-watt LED fluorescent lights with higher efficacy that can reach a minimum lux level that uses only six fluorescent lights.

3. Results and Discussion

A lighting assessment was done by observing the base case using an 18-watt fluorescent light non-LED. It was identified that the current lux was averaging below 300 lux and it did not meet the recommended design illuminance level of the Department of Energy Table 3.1 [9]. LED-fluorescent light with higher lighting efficacy was used to achieve the illuminance level of 300 to 750 lux of the classroom model, which is Room 103 of the Electrical Engineering Building. Determining the Lighting Power Density for each fluorescent light used in different scenarios to acquire the desired lumens of the classroom for each different lighting fixture set-up. Based on the cases, the proposed required number of lamps needed in the area of the model with the dimension 10.5 meters by 6.85 meters is 6 lamps; the lumen method was used to calculate the recommended number of lamps for the specified area, providing ideal lighting and energy efficiency [20].

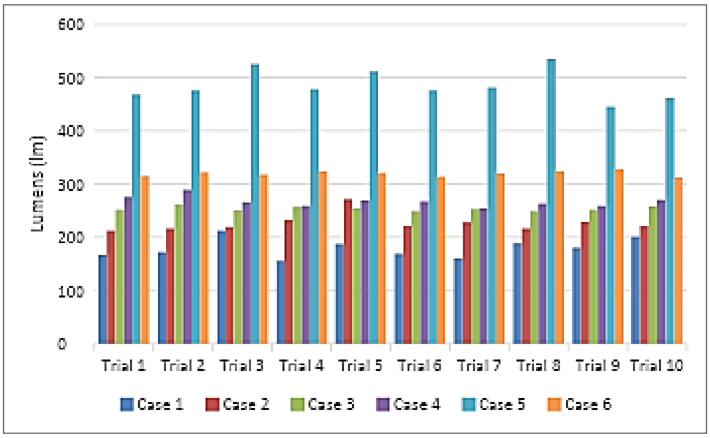

Figure 3. Cases 1 to 6 Average Total Lumens per Trial

Figure 3 presents the variations of lux measurements from Cases 1 to 6. Trial 1 shows the average lux measurements for Day 1 with testing hours of 7 am to 7 pm; the same thing was done for Trials 2 to 10. Case 1 shows a substandard illuminance level compared to Case 5, which is consistent with its high illuminance level. Cases 2, 3, and 4 show that the difference in lux is minimal compared to Cases 1, 5, and 6. It reflects how distinctly different illumination readings are through the various cases. The figures show that the lux readings for Cases 5 and 6 tend to be higher compared to the model of Case 1. The imbalance in lux measurements proves the effectiveness of Cases 5 and 6 in increasing overall brightness and improving visibility throughout the classroom. Such findings underscore the importance of lighting systems that should be upgraded to achieve high-quality lighting. Moreover, this comparison reveals further value on how lighting should be assessed, or better yet, the implications of regular lighting assessments.

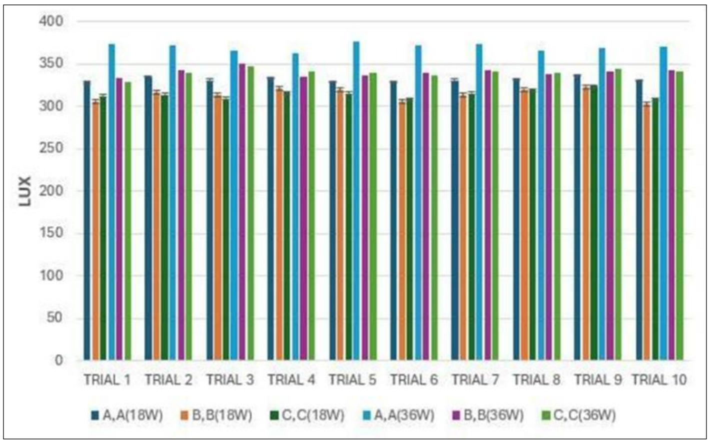

Figure 4. Cases 5 and 6 lux data using selective switching method

As shown in this figure, the proposed lighting layout in Figure 2 maximizes the natural light by still complying with the illuminance standard by just using the (A) switches of the 36W LED. (A) switches is positioned in the middle part of the classroom and it was distant from the natural light coming from the window getting 350 lumens of the area when the switches are turned on, whereas (B) and (C) switches are placed near at the window area are able to receive additional lumens from natural light while the two switches are off and resulted 300-330 lumens.

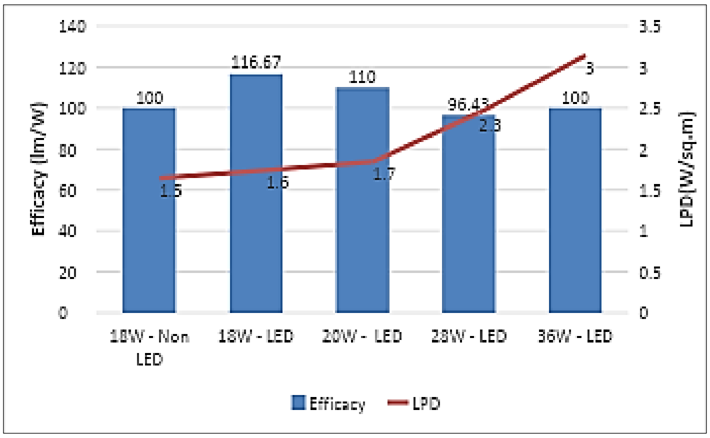

Figure 5. Lighting Efficacy and Light Power Density of Different Fluorescent Lamps

Figure 5 shows the 18W LED. The LPD is slightly higher at 1.6 W/sq.m compared to 18W non-LED. The LPD continues to increase to 1.7 W/sq.m for the 20W LED, 2.3 W/sq.m for the 28W LED, and peaks at 3 W/sq.m for the 36W LED. The efficacy of 18W LED improves to 116.67 lm/W, then drops to 100 lm/W for the 18W non-LED. The efficacy further decreases to 96.43 lm/W for the 28W LED. In general, LED lights show greater efficacy when compared to non-LED lights, signifying better energy efficiency [9]. In other words, for every watt of electricity used, LED can produce more light. It was also discovered that as the Light Power Density rises, the LED light wattage increases as well.

Greater power consumption per square meter of illuminated space is shown below by higher LPD values.

Table 1. Specification of Different Wattages Comparison

Wattage	**Luminous Flux**	**Pricing**	**Type of Lamp**	**Life Hours**
18	1800	Php. 200	Non-LED	10,000
18	2100	Php. 390	LED	22,000
20	2200	Php. 595	LED	15,000
28	2700	Php. 880	LED	22,000
36	3600	Php. 670	LED	25,000

An 18-watt non-LED lamp lasts 10,000 hours, whereas an 18-watt LED lamp lasts 22,000 hours, with luminance levels ranging from 1800 to 3600 lumens. In comparison to lamps with less wattages, a 36-watt LED lamp, for instance, generates 3600 lumens. Considering a 36W LED, classrooms are open for an average of 250 days a year. If we consider that lights are switched on for 12 hours a day, the LED lights will last for 8 years and 5 months [8]. Lastly, when compared to 18W non-LED lamps operating 250 days a year with 12 hours each day, it will last around 3 years and 3 months [8].

Table 2. Total Energy Saving and Consumption with and without Selective Switching

Fluorescent Lamps	Total Energy Consumption per Month Without Selective Switching	Total Energy Consumption per Month with Selective Switching	Total Energy Saving per Month
18W	Php. 301.6	Php. 133.98	Php. 167.62
18W	Php. 301.6	Php. 133.98	Php. 167.62
20W	Php. 335.14	Php. 148.93	Php. 186.21
28W	Php. 469.07	Php. 208.5	Php. 260.57
36W	Php. 603.2	Php. 223.37	Php. 379.83

The monthly expenses start at PHP. 301.6 up to PHP. 603.2. Without any energy-saving techniques, these figures represent the usual operating expenses of each lamp. Selective switching comes with much lower monthly costs, starting at PHP.133.98 up to PHP. 223.37. This shows that selective switching works well for reducing energy use.

The monthly energy savings are in the range of PHP. 167.62 to PHP. 379.83. The difference of a base case 18W non-LED in terms of energy saving compared to the proposed 36W is PHP 212.21. The energy saving using selective switching is a total cost reduction achieved through the introduction of selective switching that can be seen through these savings.

The financial benefits of implementing selective switching for lighting systems are illustrated in Table 2. It is visible that considerable monthly savings are possible when they are compared to the expenses of operating lamps with and without selective switching.

4. Conclusion

The researchers concluded that their objectives for Cases 5 and 6 were achieved because the illuminance level of the classroom was improved. Also, the national illumination standard policy from the Department of Energy was strictly met. In comparison to the fluorescent lights used in Cases 1, 2, 3, and 4, the LED fluorescent lights are more affordable and have better quality and specifications. In addition, Cases 5 and 6 provide advantages regarding the components utilized and the capacity to properly light the classroom with fewer LED fluorescent lights. Using LED is one of the suggestions that can help lower operating costs and provide energy-saving potential. Planning on lighting layout and having selective switching on certain lighting fixtures using 36-watts or 18-watts can provide energy- saving potential as well.

5. Recommendations

(1) Adding 36-wattage of light, despite its illumination provided to the classrooms, maximizing the use of natural light, and having selective switching possibilities should be implemented so that specific groups of fixtures can be turned off when not in use or when unoccupied spaces are present; these can help to lower operating cost.

(2) Additionally, discontinuing the use of incandescent lighting wherever more efficient lighting is possible, such as when compact fluorescent or LED lights are present, can be done.

(3) Furthermore, illuminance standards shall not be compromised by lighting energy reduction decisions.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis, and manuscript writing equally.

References

[1] Kughn, C., & Kohlert, P. (2024). School and education lighting applications. Commercial LED Lights. Retrieved from https://commercialledlights.com/educational-applications/school-lighting/.

[2] Mackenna, M. (2023). Pros and cons of lighting upgrades. Facilities Net. Retrieved from https://www.facilitiesnet.com/lighting/article/Pros-and-Cons-of-Lighting-Upgrades--19856.

[3] Veitch, J., & Newsham, G. (2013). Lighting quality and energy-efficiency effects on task performance, mood, health, satisfaction, and comfort. J. Illuminat. Eng. Soc., 27(1). https://doi.org/10.1080/00994480.1998.10748216.

[4] Michael, T. (2023). How to choose classroom lighting: The definitive guide. Upward Lighting. Retrieved from https://upwardlighting.com/classroom-lighting/.

[5] Secom, J. (2022). Adequately-lit classrooms enhance the academic performance of pupils. ResearchGate. Retrieved from https://blog.secom.es/en/adequately-lit-classrooms/

[6] Xiao, H., Cai, H., & Li, X. (2021). Non-visual effects of indoor light environment on humans: A review. Physiol. Behav., 228: 113195. https://doi.org/10.1016/j.physbeh.2020.113195.

[7] Health and Safety Executive (2020). Human factors – Lighting. HSE. Retrieved from https://www.hse.gov.uk/humanfactors/topics/lighting.htm.

[8] Stouch Lighting (n.d.). Lighting comparison: LED vs incandescent lighting. Stouch Lighting. Retrieved from https://www.stouchlighting.com/blog/light-comparison-led-lighting-vs-incandescent-lighting.

[9] Department of Energy (2008). Guidelines on energy conserving design of buildings: Table 3.1 recommended design illumination levels. Department of Energy. Retrieved from https://www.doe.gov.ph/sites/default/files/pdf/energy_efficiency/guidelines_energy_conserving_design_buildings_v2008.pdf.

[10] BSE Class (2014). Basic lighting design electrical power & lighting installation. BSE Class. Retrieved from https://bseclass.files.wordpress.com/2014/01/2-basic-lighting-design.pdf.

[11] Dydell (n.d.). Impact of light on behavior. Dydell. Retrieved from http://www.dydell.com/en/impact-light-behavior.

[12] Tse, K. (2023). LED lighting for educational institutions: Improving learning environments. LinkedIn.

[13] Pattie, N. (2021). How LED and smart school lighting can transform learning. The Parliament Magazine. Retrieved from https://www.theparliamentmagazine.eu/news/article/how-led-and-smart-school-lighting-can-transform-learning.

[14] Partington, G. (2017). Computation for square meter. Mathematics First 100 Lessons (p. 64). Retrieved from https://www.google.com.ph/books/edition/mathematics_first_100_lessons/ncwxdwaaqbaj?hl=en&gbpv=1&dq=calculation+for+square+meter+in+area&pg=pa64&printsec=frontcover.

[15] Schmitz, A. (2021). Computation for lighting spacing. Recessed Lighting Blog. Retrieved from https://blog.recessedlighting.com/recessed-lighting-placement/?fbclid=iwzxh0bgnhzw0cmtaaar1jk65mprn4hgai8szlk7ilodooemuxh2gcn2y7tat34jlp3xphubetlg0_aem_azlzurbsgamfrcjqqp19sw2q.

[16] Fireflier Lighting Limited (2010-2024). Utilization factor for lighting computation. Fireflier Lighting. Retrieved from https://fireflier.com/know-utilization-factor-tables/.

[17] XAL (2024). Maintenance factor for lighting computation. XAL. Retrieved from https://www.xal.com/en/services/know-how/maintenance-factor.

[18] Kiziltunali, B. (2023). A literature review: The impact of light on students' learning performance. HLT Magazine. Retrieved from https://www.hltmag.co.uk/aug23/the-impact-of-light-on-students.

[19] Department of Energy (n.d.). Computation for energy consumption DOE. Department of Energy. Retrieved from https://www.energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use.

[20] Tariq, H. (2017). Lighting design by lumen method. LinkedIn. Retrieved from https://www.linkedin.com/pulse/lighting-design-lumen-method-examples-hasan-tariq/.

[21] Pampanga II Electric Cooperative, Inc. (n.d.). Celebrating affordability: Pampanga II Electric Cooperative, Inc. delivers reliable power with competitive rates. Pampanga II Electric Cooperative. Retrieved from https://pelco2.com/services/rates.

[22] BSE Class (2014). Basic lighting design electrical power & lighting installation. BSE Class. Retrieved from https://bseclass.files.wordpress.com/2014/01/2-basic-lighting-design.pdf.

[23] Partington, G. (2017). Computation for square meter. Mathematics First 100 Lessons (p. 1). Retrieved from https://www.google.com.ph/books/edition/Mathematics_First_100_Lessons/NcwxDwAAQBAJ?hl=en&gbpv=1&dq=calculation+for+square+meter+in+area&pg=PA64&printsec=frontcover.

[24] Schmitz, A. (2021). Computation for lighting spacing. Recessed Lighting Blog. Retrieved from https://blog.recessedlighting.com/recessed-lighting-placement/?fbclid=IwZXh0bgNhZW0CMTAAAR1jk65mPrN4hgAi8szlk7ilodooemuxh2gcn2y7tat34jlp3xphubetlg0_aem_azlzurbsgamfrcjqqp19sw2q.

[25] Testbook Edu Solution Pvt. Ltd. (2024). Utilization of electrical energy. Testbook. Retrieved from https://testbook.com/question-answer/a-room-12-m-12-m-is-lit-by-10-lamps-to-a-f--5d61579ffdb8bb45c2c9b0a4.

[26] XAL (n.d.). Maintenance factor for lighting computation. XAL. Retrieved from https://www.xal.com/en/services/know-how/maintenance-factor.

[27] Lee, A. (n.d.). Computation for lighting efficacy. Pressbooks. Retrieved from https://pressbooks.bccampus.ca/lightingforelectricians/chapter/efficacy/.

[28] Law Insider (2013). Lighting power density (LPD). Law Insider. Retrieved from https://www.lawinsider.com/dictionary/lighting-power.