Isabela State University Linker:
Journal of Engineering, Computing, and Technology
Volume 2, Issue 2
ISSN (Print): 3082-3676   ISSN (Online): 3082-3684
DOI: https://doi.org/10.65141/ject.v2i2.n6

Illuminating Sustainability: Innovative Approaches to Lighting Efficiency and Energy Conservation in Campus Environments

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RESEARCH ARTICLE INFORMATION

Received: August 21, 2025
Reviewed: November 22, 2025
Accepted: December 19, 2025
Published: December 31, 2025

ABSTRACT

The increasing demand for energy in educational institutions, particularly for heating, ventilation, and air conditioning (HVAC) systems and lighting, presents significant challenges for sustainability and cost management. Quirino State University–Cabarroguis Campus serves as a case study to assess the efficiency of its lighting systems and the potential for energy conservation. The study aimed to evaluate the current lighting infrastructure, identify areas for improvement, and quantify the potential for energy savings. Using structured surveys, light measurement tools, and energy consumption analytics, the research investigated the existing lighting conditions in academic buildings and offices across the campus. The results indicate that while some areas meet or exceed recommended illuminance levels, others, such as the Campus Executive Officer's office, fall significantly short. The study suggests that transitioning from fluorescent lamps to energy-efficient alternatives, such as LEDs, along with optimizing the use of natural light, can substantially reduce energy consumption. The paper calculates potential energy savings of approximately 1,252.14 kWh per month, translating to an estimated annual savings of 12,034.32 pesos. The research offers actionable insights for enhancing lighting efficiency at Quirino State University and contributes to the broader discussion on sustainable practices in educational settings. These findings provide an evidence-based basis for campus energy policies and investment decisions on LED retrofits, daylighting strategies, and future integration of smart and renewable energy systems in public universities.

Keywords: *Lighting efficiency, energy conservation, energy savings, sustainable campus, LED lighting*

Introduction

Energy consumption in buildings has risen sharply worldwide, with educational institutions contributing a significant share of electricity use due to heating, ventilation, air conditioning (HVAC), and especially lighting. In universities, lighting is one of the dominant end-uses because classrooms, laboratories, and offices require long operating hours and adequate visual comfort for learning and work. This trend poses a particular challenge for countries like the Philippines, where growing energy demand, rising electricity prices, and climate commitments push institutions to adopt more sustainable and efficient energy practices.

Global and national policies increasingly emphasize energy efficiency and sustainability in the education sector. International and local analyses describe how energy-efficient lighting, daylighting strategies, and smart controls can substantially reduce electricity use and greenhouse gas emissions in schools and universities while maintaining or improving visual comfort (e.g., Miranda et al., 2024; Riffat et al., 2024). In the Philippines, government initiatives on energy efficiency and conservation, together with emerging frameworks for green and sustainable campuses in higher education, encourage institutions to upgrade outdated lighting systems, conduct regular energy audits, and integrate energy management into campus planning.

A growing body of empirical work has examined campus lighting and energy conservation in different contexts. Studies have shown that replacing fluorescent lamps with LEDs in classrooms can yield significant electricity savings and improved lighting quality (Ghisi et al., 2019; García Botella et al., 2019; Pérez Gosende, 2019). Other investigations have used lighting audits and energy consumption intensity indicators to identify conservation opportunities in university buildings and hostels, demonstrating how targeted retrofits can reduce energy use and operating costs (Faniama et al., 2024; Khalid et al., 2012; Mulla et al., 2019). Broader analyses of campus energy management highlight strategies such as integrated LED retrofits, smart controls, and behavioral interventions to move universities toward low-carbon, nearly zero energy operations (Fonseca et al., 2018; Patil & Tanavade, 2024; Seilkhan et al., 2024).

Within this literature, researchers emphasize the importance of systematically assessing indoor lighting conditions and relating them to human factors and learning environments. Recent work on luminous performance in schools and model learning spaces illustrates how combining artificial lighting and daylight can enhance both energy efficiency and user comfort (Bhattacharya et al., 2025; Miranda et al., 2024). Reviews of indoor lighting techniques trace the evolution of technologies and design strategies for energy-saving lighting in educational and public buildings, underscoring the role of accurate lux measurements and adherence to recommended lighting levels (Montoya et al., 2017; Powers & Saad, 2022). These studies collectively show that careful measurement, design, and control of lighting systems are central to sustainable campus operations, but they are largely based on non-Philippine or metropolitan institutions.

Despite these advances, there remains a limited number of detailed case studies from Philippine state universities, particularly provincial campuses that combine room-level illuminance measurements, application of recognized lighting standards, and estimation of potential energy and cost savings from specific interventions. At Quirino State University–Cabarroguis Campus (QSU CC), preliminary observations and measurements revealed continued use of 40 W fluorescent lamps in many spaces and substantial variation in lighting performance among rooms. For example, while the Conference Room shows illuminance within recommended ranges, the Campus Executive Officer's office was measured at about 98.57 lux, which is below commonly recommended levels of around 300 lux for general office tasks, suggesting under illumination and potential implications for comfort and productivity.

Lighting design and assessment are guided by empirical standards and technical guidelines that specify recommended illuminance ranges for different interior spaces. Reference tables used in this study indicate that general offices and conference rooms should typically be maintained at around 300–750 lux, whereas circulation areas and corridors can be adequately served at lower levels, such as 50–200 lux. Philippine energy and building guidelines, together with technical tools from the Department of Science and Technology–Industrial Technology Development Institute (DOST-ITDI), provide procedures for evaluating room dimensions, calculating room indices, and determining appropriate measurement points for lux assessments. These standards and procedures form the technical and policy foundation for judging whether campus lighting systems are efficient, adequate, and aligned with broader sustainability objectives in higher education.

This study addressed the identified gaps by conducting a systematic assessment of lighting efficiency and electric energy conservation at QSU CC and situating the findings within both international research and Philippine policy directions. It builds on previous work on energy audits and lighting retrofits by applying standardized assessment forms from DOST-ITDI, room index-based sampling of measurement points, and handheld light meters to evaluate the illuminance of selected classrooms, offices, and other campus spaces against recommended light levels (e.g., Baharuddin & Ismail, 2020; Biswas et al., 2013). Using these measurements, the study classified areas as under-lit, over-lit, or adequate; quantified potential electric energy conservation and peso savings associated with replacing existing fluorescent fixtures with more efficient alternatives and optimizing the use of natural light; and identified priority areas for intervention.

The findings are expected to contribute in several ways. For the QSU administration, the results provide an empirical baseline on lighting conditions and a set of evidence-based recommendations to inform campus energy policies, budgeting for LED retrofits, and integration of lighting efficiency in broader sustainability initiatives. For the wider Philippine higher education sector, the study offers a replicable framework for lighting audits that links technical assessment methods with national standards and cost–benefit considerations, complementing international case studies with context-specific evidence from a provincial state university. For researchers and policymakers, the study enriches the literature on campus energy management by demonstrating how detailed lighting assessments in a Philippine setting can support the implementation of energy efficiency and sustainability policies in higher education.

In line with these goals, the study has three specific objectives: (1) to assess the lighting conditions of selected rooms, areas, and offices at Quirino State University–Cabarroguis Campus using established illuminance standards; (2) to identify underlit, overlit, and efficient spaces based on measured illuminance and recommended light levels; and (3) to estimate the potential electric energy conservation and associated cost savings from improving lighting efficiency and maximizing natural daylight. Through these objectives, the research aimed to fill the documented gaps in campus lighting audits for Philippine state universities and to support data-driven decision-making in campus energy management.

Methods

Research Design

This study used a quantitative, descriptive cross-sectional design to evaluate lighting efficiency and electric energy conservation potential in selected buildings of Quirino State University–Cabarroguis Campus. The design focused on measuring current indoor illuminance and related physical and electrical parameters at a single point in time, then comparing these with recommended standards to identify underlit, overlit, and efficient areas and estimate potential energy savings under alternative lighting scenarios.

Key Variables

The primary outcome variable was indoor illuminance, expressed in lux, measured at specified points within each room. Other technical variables included: (a) room dimensions (length, width, and mounting height above the working plane), used to compute the room index and determine the number and placement of measurement points; (b) type and wattage of installed lighting fixtures (e.g., 40 W fluorescent lamps versus equivalent LED lamps); and (c) estimated daily operating hours of lighting systems. Derived variables included average illuminance per room, classification relative to recommended illuminance ranges, and estimated electric energy consumption and potential savings in kilowatt hours (kWh) and pesos.

Setting and Sample

The assessment covered 67 rooms and 53 offices across academic and administrative buildings at QSU–Cabarroguis Campus. Rooms were purposively selected to represent commonly used learning and workspaces, focusing on spaces with regular daytime occupancy and reliance on either natural or artificial lighting. Inclusion criteria required that rooms be in active use during the study period and accessible for measurement; areas under renovation or with restricted access were excluded.

Instruments and Their Roles

1. Primary assessment tools

DOST–ITDI lighting assessment form provided the standardized framework for recording room characteristics, installed fixtures and illuminance readings, ensuring that measurements followed an established national technical protocol. On the other hand, handheld light meter served as the main device for measuring illuminance (lux) at each designated point within the rooms, enabling comparison with recommended levels for specific room functions.

2. Supporting measurement tools

Infrared distance meter and steel tape measure were used to determine room length, width, and mounting height of luminaires above the working plane, which were then used to calculate the room index and to design the measurement grid. Meanwhile, energy consumption data and tariff information from the local distribution utility provided the basis for estimating existing and potential electric energy use and converting kWh savings into peso savings.

3. Documentation and data management tools

Lighting assessment data sheet was used to systematically record illuminance readings, room dimensions, fixture counts and types, and observational notes for each room. On the other hand, documentary records and field notes were used to document procedures, contextual factors, and any deviations from planned procedures. Lastly, spreadsheet software was used for data encoding, computation of room index, average illuminance, energy use and savings, and for organizing outputs for analysis.

Data Collection Procedures

Data collection was conducted during the first quarter of 2024 on typical working days and within daytime office hours to reflect normal operating conditions. For each selected room, the researchers first measured the room length, width, and mounting height of luminaires using the infrared distance meter or steel tape. These dimensions were used to calculate the room index using the standard formula RI=(L×W)/(Hm(L+W))RI=(L×W)/(Hm(L+W)), and to determine the minimum number of measurement points from the recommended table.

A measurement grid was then laid out to approximate a square array of points across the room, increasing the number of points when needed to achieve a near uniform spacing. Illuminance readings (lux) were taken at each point at the working plane height with artificial lights set to their usual operating state and, when relevant, with existing window coverings left as normally used. Values were recorded on the lighting assessment data sheet, together with contextual observations such as the presence of dark curtains, obstructions, or non-functional fixtures.

Survey or interview components, where applied, were conducted with staff or occupants to gather information on typical lighting use patterns and operating hours. Participants were informed of the purpose of the study, participation was voluntary, and responses were treated confidentially, consistent with institutional ethical guidelines; no personally identifiable information was reported.

Data Analysis

For each room, illuminance readings were summarized by computing the average, minimum, and maximum values across all measurement points. These were compared with recommended illuminance ranges for the corresponding room type (300–750 lux for general offices and conference rooms; 50–200 lux for circulation areas) to classify each room as underlit, overlit, or within the acceptable range. Descriptive statistics were used to summarize the distribution of illuminance across rooms and to identify patterns by building or room function.

Energy consumption and potential savings were estimated by combining information on fixture type and wattage, number of fixtures per room, and typical daily operating hours. Existing energy use (kWh) was approximated as the product of total installed wattage and daily operating hours, scaled to an 8-hour workday and 22 working days per month, and converted to kWh and pesos using the local tariff. Alternative scenarios assumed replacement of 40 W fluorescent lamps with equivalent LED fixtures of lower wattage and, where applicable, reduced usage in rooms that could rely on standard illuminance provided by daylight. The difference between baseline and scenario energy use yielded the estimated energy conserved and associated cost savings.

To enhance validity, measurements were taken under consistent daytime conditions, and instruments were used according to the manufacturer's and DOST–ITDI guidance. Potential sources of bias, such as temporary weather changes affecting daylight levels or atypical occupant behavior, were mitigated by conducting readings under typical weather conditions, avoiding days with unusual events, and documenting any deviations in the field notes for consideration in interpretation.

Rationale for Focusing on Fluorescent versus LED Lighting

Fluorescent lamps were selected as the baseline comparator because they represented the predominant existing technology in the assessed QSU–Cabarroguis rooms and are still widely used in similar Philippine campuses. LEDs were chosen as the primary alternative scenario due to their lower wattage per delivered illuminance, longer service life, and extensive evidence of energy and cost savings in educational settings, as documented in previous campus lighting studies. Comparing these two technologies allowed the study to generate realistic estimates of potential savings from a feasible and policy-relevant retrofit pathway for the university.

Research Instruments

Assessment form from DOST-ITDI. The researchers utilized an assessment form developed by the Department of Science and Technology – Industrial Technology Development Institute (DOST-ITDI) as a foundational reference for conducting the research. This form is designed to guide the evaluation of various parameters related to lighting efficiency and energy conservation. By employing this standardized assessment tool, the researchers ensured a systematic approach to data collection, facilitating a comprehensive analysis of the lighting systems at Quirino State University – Cabarroguis Campus. The use of this form not only enhances the reliability of the data collected but also aligns the study with established scientific methodologies.

Infrared Distance Meter/ Steel Tape. To accurately measure the dimensions of the rooms and areas under study, as well as the mounting height of the lighting fixtures, the researchers employed an infrared distance meter and a steel tape measure. The infrared distance meter provides precise measurements through laser technology, allowing for quick and efficient data collection in various spatial configurations. In contrast, the steel tape offers a reliable alternative for measuring shorter distances or areas where laser measurements may be impractical. Together, these tools ensured accurate spatial data, which is crucial for assessing the effectiveness of the lighting installations and their compliance with established standards.

Handheld Light Meter. The researchers used a handheld light meter to quantify the luminance levels of the lighting materials in the assessed areas. This instrument is capable of measuring light intensity in various units, providing valuable data on the adequacy of illumination present in each room. By systematically recording these luminance levels, the researchers could evaluate whether the existing lighting systems meet the recommended standards for educational environments. This quantitative assessment is essential for identifying areas that may require enhancements or modifications to improve overall lighting efficiency and effectiveness.

Lighting Assessment Data Sheet. To systematically document the measurements obtained from the handheld light meter, the researchers employed a lighting assessment data sheet. This sheet served as a structured format for recording luminance readings alongside corresponding room dimensions and other relevant variables. By utilizing this data sheet, the researchers ensured that all collected data were organized and easily accessible for subsequent analysis. This systematic approach not only aids in maintaining clarity during data entry but also enhances the integrity and reliability of the research findings.

Documentary Analysis. Throughout the data collection process, the researchers engaged in documentary analysis to meticulously document each stage of their methodology. This documentation serves as a formal record of the research activities undertaken, providing evidence of adherence to established protocols and ensuring the transparency of the study. By capturing detailed notes on the data gathering process, the researchers established a robust framework that supports the validity of their findings and facilitates reproducibility in future studies. This thorough documentation is crucial for substantiating the research methodology and for addressing potential inquiries regarding the execution of the study.

In assessing the rooms, areas, and offices at Quirino State University – Cabarroguis Campus, the researchers utilized an assessment form and instruments provided by the DOST-ITDI. They sent request letters to the DOST-ITDI office to obtain permission to use the assessment form and the handheld light meter. With these tools, the researchers were then able to effectively evaluate the lighting conditions in the various rooms and offices at QSU – Cabarroguis Campus. As for the assessment of the rooms/areas and offices, the researchers considered the following steps:

1. Use the Infrared Distance Meter/ Steel Tape to measure the dimensions of the rooms/areas and the mounting height of the lamp in every room.
2. After measuring the dimensions of the rooms and the mounting height of the lamp in every room, calculate the minimum number of measurement points using the formula for Room Index presented at Formula 1

$$\boldsymbol{Room\ Index\ (RI)} = (\boldsymbol{L\ x\ W})/(\boldsymbol{Hm}(\boldsymbol{L}+\boldsymbol{W}))$$

Where:
L = length of interior
W = width of interior
Hm = mounting height above the working plane 0.75m – above floor of offices 0.85m – above floor of manufacturing areas

Note: Units do not matter as long as the same unit is used throughout.

3. Make a layout of every room/area that will be audited for the determination of minimum measurement points.
4. Use the Handheld Light Meter to get the illuminance reading from the points based on the prepared layout.
5. Then, record the readings in the prepared Lighting Data Sheet.
6. After recording the readings in the prepared Lighting Data Sheet, gain more information and make observations in every room/area being assessed.
7. After the assessment of every area/room, enter the data gathered in Microsoft Excel and perform the necessary computations as prescribed.
8. Finally, compare the computed lighting index and measured lux values with standard values as a reference and identify locations as under-lit and over-lit areas.

Ethical Considerations

The study sought permission from the QSU–Cabarroguis Campus administration to access buildings and conduct measurements, and obtained authorization from

DOST–ITDI to use its assessment form and instruments. Where surveys or informal interviews were conducted, respondents were briefed on the study objectives, assured that participation was voluntary and could be withdrawn at any time, and informed that data would be used only in aggregated form. No interventions were imposed on occupants during measurement, and data collection did not involve any sensitive personal information.

Results and Discussion

Room Index

Table 1. Determination of Measurement Points

Room Index	Minimum Number of Measurement Points
Below 1	9
1 and below 2	16
2 and below 3	25
3 and above	36

Source: Bureau of Energy Efficiency

To obtain an approximately "square array", i.e., the spacing between the points on each axis to be approximately the same, it is necessary to increase the number of points. For example, in Table 1, the dimensions of an interior are:

Length = 9m,
Width = 5m,
Height of luminaires above working plane (Hm) = 2m
Calculate RI = (9 x 5)/(2(9+5)) = 1.61

From Table 1, the minimum number of measurement points is 16. As it is not possible to approximate a "square array" of 16 points within such a rectangle, it is necessary to increase the number of points to 18, i.e., 6 x 3. These should be spaced as shown below:

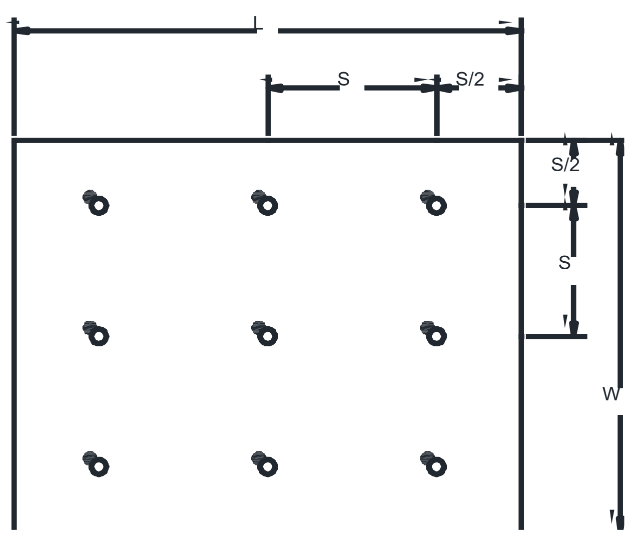

Figure 1. *Spacing of the Points for the Room with a Room Index Below 1*

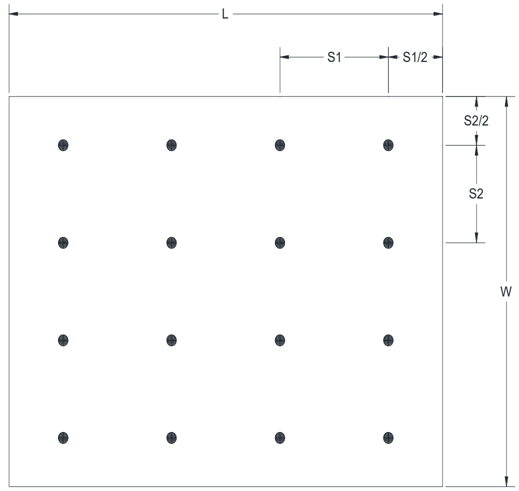

Figure 2. *Spacing of the Points for the Room with a Room Index of 1 and Below 2*

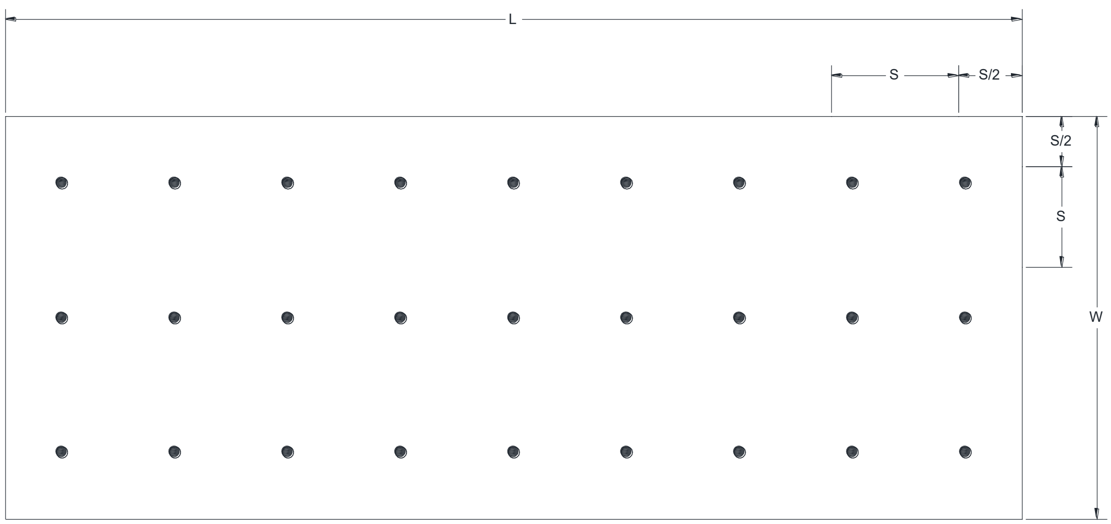

Figure 3. *Spacing of the Points for the Room with a Room Index of 2 and Below 3*

Lighting Fixtures Used

As observed from the different rooms/areas being assessed, the majority of the lighting fixtures being used are 40-Watt Fluorescent Lamp (FL). Nowadays, the use of FLs is still observed from various agencies or institutions; however, in terms of economic viability, the use of daylight is considered to be the cheapest and most energy-efficient lighting preferred method in illuminating a building.

As shown in Table 1, the majority of assessed rooms rely on multiple 40 W fluorescent lamps, consistent with the observation in the narrative that 40 W fluorescent fixtures remain the dominant technology used across campus. This configuration results in relatively high installed wattage per space, especially in areas with many fixtures, such as the library reading area and computer laboratory, and indicates considerable potential for reducing connected load through retrofitting with lower-wattage LED lamps that provide comparable or superior illuminance. The proposed LED wattage of around 18 W per fixture for these spaces is realistic for modern tubular LEDs and reflects a reduction of more than 50% in wattage per lamp while maintaining adequate light output, aligning with evidence from previous studies on LED retrofits in educational settings.

Level of Luminance

Table 2. Recommended Light Levels

Task	Minimum (lux)	Maximum (lux)	Application
Lighting for frequently used areas	50	150	Circulation areas and corridors
	100	200	Stairs, escalators
	100	200	Bedrooms, lavatories
Lighting for working interiors	200	300	Infrequent reading and writing
	300	750	General offices, typing, and computing
	300	750	Conference rooms
	500	1000	Deep-plan general offices
Localized lighting for exacting work	500	750	Proofreading
	1000	1000	Drawing offices
	500	500	Designing architecture and machine engineering
	1000	1000	Detailed and precise work

Source: Guidelines for Energy Conserving Design of Buildings and Utility Systems by the Department of Energy

As presented in Table 2, the conference room within the administration building exhibited the highest recorded luminance level, measuring at 228 lux. This elevated luminance can be attributed to the maximum recorded level in the area, which reached 407 lux. This suggests that the conference room is well-equipped to meet the lighting demands for activities conducted within it.

The measured illuminance values in Table 2 highlight clear disparities between rooms when compared with the recommended illuminance ranges from the Department of Energy guidelines for energy-conserving design of buildings. The conference room recorded an average illuminance of 228 lux, below the recommended 300–750 lux range for conference and general office spaces, but still relatively close to the lower bound, suggesting that the space can accommodate meetings and discussions with acceptable visual comfort, especially when supported by natural light. In contrast, the Registrar's Office, with an average of about 195 lux, and particularly the Campus Executive Officer's office, with only 98.57 lux, fall markedly below the recommended 300 lux minimum for general office environments, indicating that occupants in these rooms are working under under-lit conditions that may compromise visual comfort and task performance.

In contrast, the Registrar's Office recorded a luminance level of 195 lux, positioning it as the second highest among the assessed rooms and areas. While this level is adequate for many office tasks, it still falls short of the optimal lighting conditions recommended by the Department of Energy (DOE).

Conversely, the Office of the Campus Executive Officer demonstrated the lowest luminance level among the assessed spaces, measuring only 98.57 lux. This significant shortfall highlights a potential issue in achieving adequate lighting for effective work performance, especially considering the DOE's recommended minimum luminance level of 300 lux for general offices, including spaces designated for typing and computing. The maximum recommended level is 750 lux, indicating that both the Registrar's Office and the Campus Executive Officer's office could benefit from improvements to their lighting systems to meet the established standards.

Computation of the Savings

The computation of the savings was computed using the formula presented below:

$$\boldsymbol{Kilowatt\ Hour\ (KWH)\ Used\left(\frac{Wattage}{1000}\right)(No.of\ Working\ Hours\ per\ day)}$$

Formula 2

$$\boldsymbol{Electric\ Charge\ Rate\ Per\ Day = KWH\ x\ Rate\ perKWH\ (PhP)}$$

Formula 3

$$\boldsymbol{Rate\ per\ Month = Rate\ per\ Day\ x\ 22\ days\ per\ month}$$

Formula 4

$$\boldsymbol{Rate\ per\ Year = Rate\ per\ Month\ x\ 12\ Months\ per\ Year}$$

Formula 5

Where:
Rate per KWH = PhP 9.6110 (based on QUIRELCO for May 2019)
1000 = Conversion from Watt to Kilowatt
22 Days = Regular working days in a month

Note: In computing the energy conserved and savings, only consider the rooms with standard luminance provided by natural light, since the electric energy used for lighting systems was not necessary during office hours. For the rooms that needed to be illuminated by artificial lights to attain the recommended light level, they are exempted from the computation of energy conserved and savings.

The assessment of lighting conditions and installed fixtures at Quirino State University–Cabarroguis Campus revealed a strong reliance on conventional 40 W fluorescent lamps across key academic and administrative spaces, alongside notable variation in indoor illuminance relative to recommended standards. In total, a set of representative rooms and areas was evaluated, including the Conference Room, Registrar's Office, Campus Executive Officer's office, Records and Cashier's Offices, classrooms, a computer laboratory, a faculty room, the library reading area, and main corridors in the Administration and Academic Buildings. These spaces reflect typical learning, administrative, and circulation environments where lighting plays a crucial role in visual comfort, safety, and energy use. Table 1 summarizes the number and type of fixtures installed, while Table 2 presents measured illuminance levels for selected rooms against recommended ranges.

Narrative observations during measurement provide additional context to these quantitative findings. The report notes, for example, that the Conference Room benefits from relatively unobstructed windows and lighter interior finishes, which help distribute available light and likely contribute to the higher illuminance values observed, including maximum measured levels reaching 407 lux at certain points. By contrast, the Campus Executive Officer's office was found to have darker furnishings and window treatments, including dark-colored curtains that partially block natural light, contributing to the low average illuminance of 98.57 lux and underscoring how room layout and interior design influence effective lighting levels. These qualitative details help explain why some spaces, despite using similar fixture types and wattages, exhibit very different lighting performance and highlight the importance of both equipment and environmental factors in achieving recommended standard levels.

When these illuminance patterns are translated into energy terms, the analysis shows that there is a substantial opportunity for electric energy conservation by better aligning lighting operation with actual need and by optimizing the use of natural light. The study calculated that, considering only rooms where natural light alone already provides illuminance within recommended ranges during office hours, the potential electric energy conserved by not using artificial lights in those spaces is 56.93 kWh per day. Assuming a typical month with 22 working days, this equates to approximately 1,252.14 kWh of conserved energy per month, representing a meaningful reduction in electricity use attributable solely to improved operational practices in adequately daylit rooms. Using the QUIRELCO electricity rate of 9.6110 pesos per kWh for May, the corresponding monetary savings were estimated at 12,034.32 pesos for that period, illustrating that even modest operational changes can generate noticeable financial benefits for the university.

Importantly, the computation of energy savings deliberately excluded rooms that depend on artificial lighting to reach the minimum recommended illuminance levels, such as the Campus Executive Officer's office and other underlit spaces. In these rooms, artificial lighting is necessary to achieve acceptable visual conditions, so switching off or significantly reducing electric lighting would violate recommended standards and could impair comfort, safety, and productivity. By limiting the savings calculations to rooms where daylight alone already satisfies standard illuminance requirements, the study provides a conservative, realistic estimate of potential energy and cost savings that does not rely on sacrificing visual performance. This approach reinforces the conclusion that there is a dual path forward: first, to remedy under-lighting in critical offices and workspaces through fixture upgrades, layout changes, or brighter but efficient lamps, and second, to capture operational savings in already well-lit or overlit areas through behavioral measures and lighting controls.

Overall, the results reveal a campus lighting profile characterized by widespread use of 40 W fluorescent fixtures, significant under-lighting in specific administrative rooms, and underutilized opportunities for energy savings in areas where daylight is sufficient. The measured illuminance values and computed energy saving potential align with findings from other campus lighting audits that document similar patterns of outdated lighting technologies, uneven light distribution, and substantial benefits from targeted retrofits and improved control strategies. For Quirino State University–Cabarroguis Campus, these results provide a concrete evidence base for prioritizing LED retrofits in underlit and high-consumption rooms, revisiting interior design elements that block natural light, and developing policies or guidelines for switching off electric lighting in adequately daylit spaces, thereby improving both the quality of learning and working environments and the efficiency of campus energy use.

Conclusion and Future Works

The study concludes that lighting conditions at Quirino State University–Cabarroguis Campus are mixed: many rooms that benefit from natural daylight meet or closely approach recommended illuminance standards, while several key offices remain substantially underlit, and there is measurable potential for electric energy conservation through more efficient technologies and operational practices. These conclusions directly reflect the objectives of assessing lighting conditions, classifying spaces relative to standards, and estimating potential energy and cost savings from improved lighting efficiency.

In relation to the first objective, the assessment showed that spaces such as the Conference Room achieve average illuminance close to recommended levels, whereas the Campus Executive Officer's office and other administrative areas operate below the 300 lux minimum for general office tasks, indicating a need for targeted improvements in those rooms. This uneven pattern confirms that current lighting provision is adequate in some learning and meeting spaces but insufficient in certain workspaces where sustained visual tasks are performed, with implications for occupant comfort, productivity, and the overall quality of the campus work environment. Addressing under-lighting in these priority rooms through measures such as fixture upgrades, layout adjustments, or enhanced use of daylight emerges as an immediate practical recommendation for the university.

For the second and third objectives, the study's comparison of measured illuminance with Department of Energy guidelines and its energy calculations demonstrates that the existing building configuration and available daylight can support significant energy conservation without compromising visual standards, provided that artificial lighting in adequately daylit rooms is used more judiciously. The analysis indicates a potential conservation of 56.93 kWh per day, or approximately 1,252.14 kWh per month, when lights are switched off or reduced in rooms that already meet recommended illuminance through natural light, corresponding to an estimated savings of about 12,034.32 pesos at the prevailing QUIRELCO tariff. These figures underscore that relatively simple management actions and retrofitting from 40 W fluorescent lamps to more efficient LED fixtures can yield tangible financial benefits for the campus, supporting the integration of lighting efficiency into broader energy and sustainability plans.

The results carry concrete policy and practice implications for QSU administration and for sustainability efforts in Philippine higher education. For campus management, the findings provide an empirical basis for prioritizing resources toward LED retrofits in underlit and high-consumption spaces, revising interior elements that unnecessarily block daylight (such as dark curtains), and instituting guidelines or controls to ensure that artificial lighting is used only when needed in rooms with adequate natural light. At a broader level, the study offers a replicable framework—anchored in DOE standards and DOST–ITDI assessment tools—that other state universities can adapt to conduct lighting audits, estimate realistic energy savings, and align campus operations with national energy efficiency and sustainability policies. By quantifying both illuminance gaps and achievable savings, the research contributes evidence that can inform institutional energy policies, capital budgeting, and the development of campus-wide sustainability programs.

Several limitations and constraints should be acknowledged to frame these conclusions appropriately. Measurements were taken during a specific period under typical, but not fully controlled, daylight and weather conditions, so short-term variations in sky conditions and occupant behavior may have influenced recorded illuminance and energy use patterns. The sample of rooms, while including representative administrative and academic spaces, does not cover every building or room type on campus, which may limit the generalizability of specific numeric estimates to the entire university. In addition, the energy savings computations relied on assumed operating hours and did not incorporate long-term behavioral changes or detailed statistical analysis of variance in illuminance beyond descriptive summaries, which should be refined in future work.

These limitations suggest clear directions for further research. Future studies could expand the sample to additional buildings and room types, incorporate continuous or time-series measurements to capture diurnal and seasonal variations in daylight and occupancy, and apply more advanced statistical analyses to evaluate uniformity, variability, and user perceptions of lighting. Further work could also simulate or pilot LED retrofit scenarios and smart control systems (such as occupancy sensors and daylight-linked dimming) to validate the estimated savings and to explore how these technologies interact with user behavior in practice. By building on the present study's campus-specific evidence and addressing its methodological constraints, subsequent research can deepen understanding of how Philippine higher education institutions can systematically improve lighting efficiency, enhance indoor environmental quality, and contribute more effectively to national energy efficiency and sustainability goals.

Future research at Quirino State University – Cabarroguis Campus can significantly enhance lighting efficiency and energy conservation through several promising avenues. Implementing proposed lighting system improvements paired with real-time monitoring would allow for accurate measurement of their impact and ongoing optimization. Exploring smart lighting solutions, such as automated controls and sensors that adjust based on occupancy or natural light availability, could further increase energy efficiency. Integrating renewable energy sources, like solar panels, into the lighting framework could reduce reliance on the electrical grid and lower operational costs, particularly in sunlit areas. Expanding the study to include dormitories, laboratories, and recreational spaces would provide a holistic view of energy usage, enabling targeted improvements in high-consumption areas. Examining how environmental factors, such as indoor temperature, humidity, and room layout, influence lighting efficiency could yield valuable insights for optimizing energy strategies in educational settings.

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Conflict of Interest

The authors declare that they have no conflict of interest in the publication of this research paper. No financial or personal relationships with other people or organizations have influenced the conduct of this research or the preparation of this manuscript.

Artificial Intelligence (AI) Declaration Statement

The researchers hereby declare that AI tools were used in the preparation of this study, particularly in refining the clarity and coherence of the discourse. Grammarly was also used to ensure the grammaticality of all the details of the research. The AI tools were not used to generate and analyze research data, interpret results, and make conclusions based on the findings of the study.