Real-Time Telemetry Based Monitoring System for Energy Efficiency Evaluation of Scheduled Dimming in Office Corridor Lighting

Muhammad Risqi Nuryana
Program Studi Magister Teknik Elektro
Universitas Katolik Indonesia Atma Jaya
Jakarta, Indonesia
mrisqinuryana@gmail.com

Veronica Windha Mahyastuty
Program Studi Teknik Elektro
Universitas Katolik Indonesia Atma Jaya
Jakarta, Indonesia
veronica.may@atmajaya.ac.id

Ridwan Satrio Hadikusuma
Program Studi Teknik Elektro
Universitas Pamulang
Tangerang Selatan, Indonesia
dosen03333@unpam.ac.id

Abstract—In many office buildings, corridor lighting systems are commonly operated at full brightness continuously, regardless of occupancy conditions, resulting in unnecessary energy consumption. This study proposes and evaluates a real-time telemetry-based monitoring system to assess the energy efficiency of a scheduled dimming strategy for office corridor lighting. The developed system integrates dimmable LED luminaires with a telemetry unit capable of transmitting real-time illuminance and energy consumption data for monitoring and analysis. A time-based dimming schedule of 25%, 50%, and 75% output levels was implemented in an office corridor environment. Illuminance measurements were collected at five different points along the corridor, while electrical energy consumption was recorded continuously over a seven-day observation period through the telemetry monitoring platform. The results indicate that even at the lowest dimming level (25%), the corridor maintained an average illuminance of 100 lux, which remained within acceptable lighting standards for pedestrian circulation. Telemetry data further demonstrated that the scheduled dimming strategy reduced weekly energy consumption by approximately 64% compared to continuous full operation (0.711 kWh reduced to 0.253 kWh). These findings confirm that real-time telemetry monitoring enables accurate performance evaluation of lighting control strategies while ensuring compliance with visual comfort requirements. The study highlights the potential of telemetry-based lighting monitoring systems as an effective approach to optimize energy use, minimize over-lighting, and support data-driven energy management in office buildings.

Keywords—Real Time Telemetry, Energy Efficiency, Corridor Scheduled Dimming, Illuminance Measurement, Smart Lighting Control

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I. INTRODUCTION

Lighting is still one of the most operationally flexible energy end uses in buildings, meaning that meaningful savings can be achieved not only by upgrading luminaires, but also by improving how the lights are operated and controlled day to day [1]. A consistent message in recent literature is that the magnitude of savings depends strongly on the control approach (manual vs. automated), the control granularity (zone vs. luminaire-level), and how the control settings match real occupancy patterns and facility routines [2].

In office buildings, this issue becomes very visible in transitional areas such as corridors. Corridors require adequate lighting for safety and wayfinding, but in practice they are also among the spaces most likely to be operated. For example, lights being switched on early and left on for long stretches even when traffic is intermittent. For many facilities, the most realistic first step to reduce this waste is not immediately installing sensors everywhere, but introducing a structured control logic often starting from simple time-based scheduling.

Over the last decade, research on lighting controls has expanded from conventional occupancy sensors and daylight dimming into networked and connected lighting, where

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control settings, zoning, and system feedback can be managed and monitored more consistently. Reviews and simulation based studies show that higher resolution control can unlock higher savings, but they also highlight an important practical point: performance is highly sensitive to commissioning choices such as timeout, grouping, and dimming versus off behavior. In other words, “smart” does not automatically mean “efficient” unless the strategy and settings are aligned with the space function [3] [4].

Beyond control strategy selection, the hardware level implementation of dimming also plays a significant role in determining how efficiently lighting energy is converted to useful output. Studies on LED driver behavior have shown that conventional PWM dimming, despite its widespread adoption, fails to exploit the nonlinear current-illuminance characteristic of high brightness LEDs, meaning that the same power input can yield substantially different luminous output depending on how the dimming signal is structured [5]. Multilevel current dimming approaches have been reported to raise overall luminous efficiency by more than 20% under equivalent power consumption, reinforcing that dimming method selection is not merely a hardware preference but a factor with direct consequences for the energy yield per delivered watt [5] [6]. At the controller level, a sensor-driven autonomous system employing optimized PWM feedback logic has been demonstrated to sustain target illuminance levels in a real office environment while measurably reducing active power draw, showing that hardware-level and algorithm-level decisions in LED system design are closely linked to broader building energy-saving outcomes [7].

At the same time, many buildings especially existing ones face implementation constraints that rarely appear in idealized control studies. Examples include shared electrical circuits, limited metering resolution, and operational needs that require predictable lighting availability. Studies discussing lighting control deployment in real buildings point out that occupant overrides, building schedules, and operational routines can significantly reshape the expected savings from automated control, sometimes reducing the benefit if the control logic conflicts with actual usage [8]. This is precisely why corridor-focused case studies remain relevant: corridor use is strongly schedule-driven in many offices, yet still prone to over-operation [9].

Time based scheduling offers a practical compromise in this context. Unlike occupancy or daylight based control, scheduling does not require additional sensing hardware, calibration, or continuous detection reliability [10]. It reduces energy primarily by limiting operating hours, making it attractive for facilities that want quick, low disruption changes. Evidence from field oriented studies shows that scheduled shut off or scheduled operating windows can provide clear energy and cost savings in large building areas that would otherwise be illuminated for long durations [11]. In addition, corridor retrofit studies demonstrate that control strategies whether scheduling, occupancy, daylight, or their combination can significantly affect corridor lighting energy use, reinforcing that secondary spaces are a meaningful target for operational efficiency improvements [12].

Nevertheless, scheduling-only control is not simply about “turning lights off earlier.” Corridor lighting still needs to maintain adequate illuminance and user acceptance, and the operational window must be chosen carefully to avoid under-lighting during unexpected use. Broader research on user-centred lighting control emphasizes that real-world performance is influenced by how controls interact with people and routines, and by how well the control intent is communicated and understood [13]. For this reason, an evaluation that combines energy data with a basic lighting quality check illuminance measurement is important even for a straight forward scheduling strategy [14] [15].

Therefore, this study evaluates the energy efficiency of a scheduling-based corridor lighting system implemented in an office building. The analysis compares corridor-zone lighting energy consumption and operating hours before and after the scheduling policy is applied, using energy data available at the corridor zone level from the lighting management system. To ensure that the energy reduction does not compromise lighting

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performance, illuminance measurements are also conducted in the corridor during scheduled operation. By focusing on a real operational configuration scheduling without additional sensors this work aims to provide practical, data-driven evidence that can be directly used by facility teams considering a low-complexity lighting control upgrade.

The novelty of this study lies in its practical evaluation of scheduling-based corridor lighting using real operational data from a smart lighting platform (Interact/BMS), incorporating step dimming levels and illuminance verification to ensure both energy savings and visual comfort. Table 1 summarizes the unique contributions of this research compared to previous work.

Table 1. Novelty / Contribution of This Study

Aspect	Novelty
Zone Focus	Analysis limited to corridor lighting zone, which is often overlooked in previous studies.
Schedulling Strategy	Use of step dimming (10%, 30%, 55%) rather than simple ON/OFF scheduling.
Data Source	Real Interact/BMS data (kWh per corridor zone) instead of simulation-only studies.
Before After Comparison	Direct baseline vs scheduling comparison using measured energy and operating hours.
Illuminance Verification	Spot-check lux measurement to ensure visual comfort while saving energy.
Applied Context	Case study conducted in real office building corridor, reflecting practical implementation constraints (shared circuit with office, no sensors).
Energy Analysis	Quantification of both absolute and percentage energy savings, plus operational profile visualization (hourly/step-dimming).

II. METHODOLOGY

This study evaluates the effectiveness of a scheduled dimming strategy in reducing corridor lighting energy consumption while maintaining acceptable illuminance levels for pedestrian visibility. The research was carried out through a sequence of system identification, scheduling configuration, field measurement, and energy monitoring activities. The measurement results were then validated and compared with a full lighting operation scenario to quantify potential energy savings.

The experimental workflow was designed to reflect actual building operation conditions, where corridor lighting output varies depending on occupancy and time of use. The overall research procedure, including measurement and validation steps, is illustrated in Figure 1.

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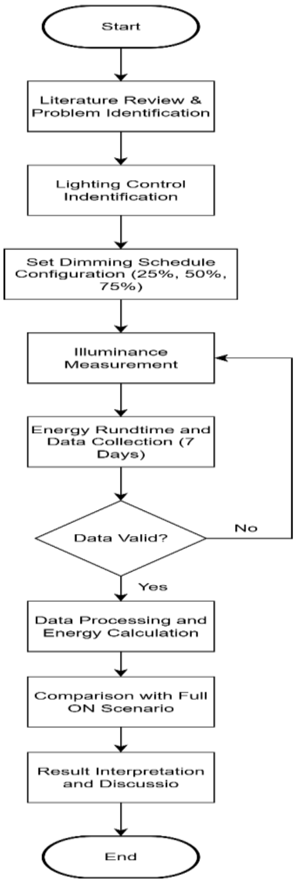

Figure 1. Research Flowchart

The study was conducted in an office corridor with a width of approximately 1.5 m and a ceiling height of 3 m, representing a typical circulation space in office environments. The corridor lighting system consists of three recessed LED luminaires installed along the corridor axis with relatively uniform spacing to provide continuous illumination along the walking path. This configuration was selected as it reflects common corridor lighting practice where luminaires are arranged linearly to maintain visibility and visual comfort for pedestrian movement. The physical dimensions and luminaire arrangement were considered during the evaluation, as they directly influence illuminance distribution and the resulting energy performance of the scheduled dimming strategy.

A. System Identification and Scheduling Setup

The experiment was conducted in an office corridor equipped with recessed LED luminaires connected to a centralized lighting control system. The luminaires support dimming functionality and are operated using a scheduling-based control approach. Prior to the measurement process, the corridor layout, luminaire placement, and control grouping were reviewed to ensure stable operating conditions and consistent measurement results.

The installed luminaire represents a typical corridor lighting fixture used in commercial office buildings. The technical characteristics of the luminaire were considered to ensure consistency between lighting performance and energy analysis. The detailed specifications of the luminaire used in this study are presented in Table 1.

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Table 2. Luminaire speification

Parameter	Value
Model	DN391X LED WIA WH
Light Source	LED
Lumen	1300
CCT	4000 K
CRI	>80
Input Voltage	220-240 VAC
Dimmable	Yes

A step-dimming schedule was configured through the lighting control platform to represent realistic corridor usage patterns. The luminaires remained off during low-activity periods and gradually increased output during occupied hours. The implemented schedule consisted of 25% output from 12:00–15:00, 50% from 15:00–17:00, and 75% from 17:00–20:00. This scheduling approach was selected to evaluate the trade-off between energy efficiency and lighting adequacy in corridor environments. Following the scheduling configuration, field measurements were performed to assess illuminance distribution under each operating condition.

B. Research Parameter and Variables

This study evaluates both lighting performance and energy consumption under scheduled dimming operation. To clarify the measurement scope and analysis basis, the main research parameters and variables considered in this study are summarized in Table 3.

Table 3. Research parameters and variables

Category	Parameter	Description
Lighting Performance	Illuminance (lux)	Measured at five corridor points under different dimming levels
Energy Performance	Energy consumption (kWh)	Obtained from Interact monitoring platform
Operational Parameter	Dimming level (%)	25%, 50%, 75% scheduled operation

C. Illuminance Measurement Procedure

Illuminance measurements were conducted to evaluate whether the applied dimming schedule maintained adequate corridor visibility. Five measurement points were selected along the corridor pathway to represent typical walking areas and to capture the overall lighting distribution. The points were positioned along the central walking path and distributed across the corridor length to avoid bias caused by proximity to individual luminaires. This placement was intended to provide a representative indication of overall corridor illuminance and to evaluate lighting uniformity under different dimming levels. Measurements were taken using a portable lux meter positioned at the visual plane relevant to pedestrian movement. Measurements were taken using a portable lux meter positioned at the visual plane relevant to pedestrian movement.

To improve measurement consistency, readings were recorded after the lighting output stabilized at each dimming level. The obtained values were then averaged to represent the illuminance condition for each operating period, reducing potential fluctuations caused by sensor response and environmental variation. The distribution of measurement points along the corridor is illustrated in figure 2 while an example of the field measurement setup using a lux meter is presented in figure 2.

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Figure 2. Measurement points for illuminance in the corridor.

D. Energy Data Collection and Analysis

Energy consumption and operating runtime were obtained from the building lighting control platform over a continuous seven-day observation period. The monitoring data were extracted directly from the Interact system, which provides runtime duration and estimated energy usage based on luminaire operating levels and scheduling configuration.

Prior to analysis, the recorded data were reviewed to ensure consistency between system runtime and the configured dimming schedule. This verification step was necessary to avoid discrepancies caused by unexpected manual operation or communication interruptions.

In addition to monitored data, theoretical energy consumption was calculated using the rated luminaire power and scheduled dimming percentages under the assumption of linear dimming behavior. The calculated values were used to support the monitoring results and to establish a comparison with a full lighting operation scenario. The analysis focused on weekly energy consumption and the relationship between energy reduction and maintained illuminance performance.

III. Result and Discussion

A. Illuminance Performance Under Scheduling Dimming

Measured illuminance values from the corridor are presented in Table 3 and the range in values due to dimming level is shown in Figure 3. The results indicate that illuminance continuously increases and is proportional to the increasing percentage of lighting output used. At all measurement points the results show stability which means that there is an absence of dark zones in the corridor.

Table 4. Measured Corridor Illuminance at Each Dimming Level

Measurement Point	25%	50%	75%	100%
P1	117	192	256	345
P2	108	185	241	325
P3	114	191	252	343
P4	110	187	247	333
P5	112	184	246	334
Average	112,2	187,8	248,4	336

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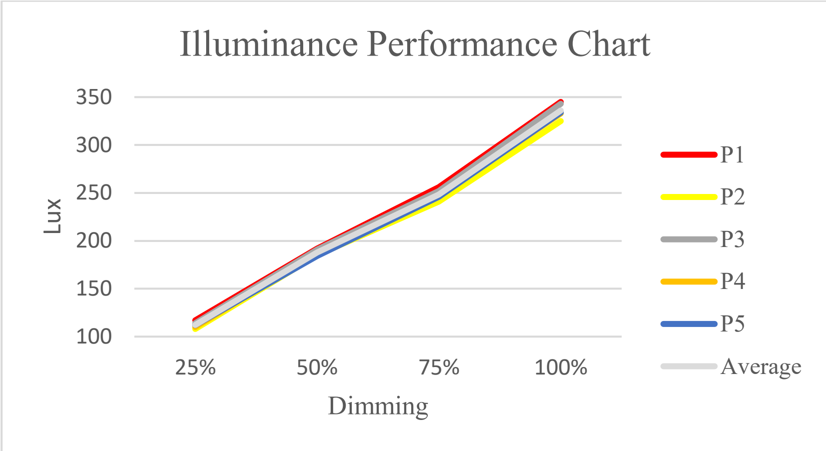

Figure 3. Illuminance performance chart

The average illuminance in the corridor at the lowest operating level is 110 lux which is already above the recommended level for circulation areas. The recommended level of illuminance at corridor areas is 100 lux, therefore, the increase in average illuminance values to 187.8 lux and 248.4 lux at 50% and 75% dimming levels respectively, results in better vision at the level of clean visual and providing the uniformity at all measurement points. The average illuminance in the corridor at max lighting output level of 336 lux, gives an indication that the lighting system in corridor is above average superior.

From practical estimates, lighting system in the corridor can be operated at reduced levels to ensure that the movement of all pedestrians is unrestricted and safe. Based on the results, the uniformity be maintained in all the measurement points and dimming can be used in a safety manner.

B. Energy Consumption Under Scheduled Dimming

Summary of monitored energy consumption for each scheduled dimming period we can see in table 4. Data were collected from lighting control platforms from 12:00 to 20:00 during daily operating windows. The results indicate that energy consumption differed across dimming levels, demonstrating real luminaire power at varying output levels.

Table 5. Measured energy consumption under scheduled dimming

Operating Period	Dimming	Duration	Energy (Wh)	Energy (kWh)
12-15	25%	3 Hours	9.2	0.0092
15-17	50%	2 Hours	10	0.010
17-20	75%	3 Hours	17	0.017
Total	-	8 Hours	36.2	0.0362

For 25% dimming levels, over a 3 hour period, corridor lighting drew 9.2 Wh, which is a consumption that is minimal considering the trade off of losing some visibility. 50% dimming levels resulted in 10 Wh consumed over 2 hours, and 75% levels consumed 17 Wh over 3 hour. Dimming strategy energy consumption for the entire day was measured at 36.2 Wh, or 0.0362 kWh.

The higher the dimming levels, the more energy consumption is used is what these results illustrate, and while the daily usage is not significant, it is noticeable. The data monitored also illustrate the unpredictable behavior of LED luminaires when dimmed, where energy consumption is reduced, but not to the expected extent.

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C. Energy Saving Compared to Full Operation

A comparison between scheduled dimming and continuous full lighting operation is presented in table 5, with the overall trend illustrated in figure 4. The daily energy consumption under full operation was calculated at 0.1016 kWh, whereas the scheduled dimming strategy resulted in a monitored daily consumption of 0.0362 kWh. Over the seven day observation period, this corresponds to a reduction from 0.711 kWh to 0.253 kWh.

Table 6. Energy consumption and saving comparison

Operating Mode	Daily Energy (kWh)	Weekly Energy (kWh)	Rate Saving
Full On	0,1016	0,7112	-
Step Dimming	0,0362	0,2534	-
Energy Saving	0,0654	0,4578	64%

The observed reduction indicates approximately 64% energy savings, confirming the effectiveness of scheduling-based dimming for corridor lighting applications. The energy gap between the two scenarios suggests that continuous full operation leads to unnecessary energy usage, particularly during periods of low corridor activity.

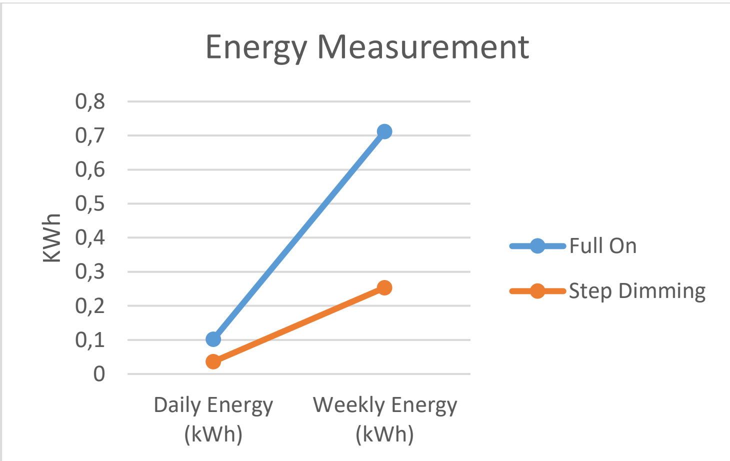

Figure 4. Comparison of daily and weekly energy consumption

These findings highlight the practical advantage of applying time based control strategies in circulation areas, where lighting demand does not remain constant throughout the day. The results also emphasize the importance of monitoring-based evaluation, as real energy behavior may differ from theoretical estimation due to luminaire driver characteristics

D. Relationship Between Illuminance and Energy Efficiency

An important insight from this study is that most of the energy used for lighting was saved while still maintaining the same lighting performance. Even when the lights were dimmed to 25%, the brightness of the corridor was still above the recommended brightness. This shows that lighting systems do not always need to be operated at full capacity for normal corridor usage.

This study shows that there is most likely over-lighting within the systems used for continuously operated corridors. If the lighting output is attuned to the real needs of the system user, it is possible to achieve a high level of energy savings while meeting the user's visual comfort and safety. Reduction of corridor lighting energy consumption during

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scheduled dimming is a sensible and direct corridor lighting energy saving solution for office buildings.

E. Future Discussion

This study shows that scheduled dimming is an effective method for improving efficiency of corridor lighting, there are multiple aspects that can be looked at during future studies. Future studies can include the use of occupancy-based control that can help dimming systems save more energy by operating lights on an as-needed basis using real-time corridor usage data. Longer monitoring periods would also help determine energy performance more accurately and completely during a variety of operational periods.

Future studies also have a lot of potential when it comes to evaluating the perception and visual comfort of building occupants during periods of extended occupancy. One possible avenue that has not yet been explored integrated control of corridor lighting with building management systems or IoT-based monitoring systems to optimize energy use.

IV. Conclusion

This research demonstrates that the implementation of a real-time telemetry-based monitoring system enables accurate evaluation of a scheduled dimming strategy for office corridor lighting. The results confirm that scheduled dimming significantly reduces energy consumption while maintaining appropriate lighting levels for corridor activities. Measurement data indicate that even at a 25% dimming level, the corridor illuminance remained above the recommended standard, showing that continuous full lighting operation is not necessary for normal circulation areas. Telemetry-based monitoring further revealed that the proposed scheduled dimming strategy achieved approximately 64% weekly energy savings compared to continuous full operation (0.711 kWh reduced to 0.253 kWh). The integration of real-time data acquisition and monitoring enhances the reliability of performance evaluation by capturing actual energy behavior under operational conditions. Overall, the findings highlight that a telemetry-supported scheduled dimming system provides an effective approach to balance energy efficiency, visual comfort, and compliance with office lighting standards. This study also emphasizes the role of telemetry systems in enabling data-driven energy management strategies for modern office buildings.

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