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Comprehensive Energy Performance Assessment of a Lecturer Building in a Malaysian Public University

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Abstract

The increasing energy consumption of public university buildings in Malaysia has raised concern, particularly regarding the energy performance of lecturer rooms which is a topic often overlooked in broader campus-level studies. This research addresses that gap by analysing the energy usage patterns of the C16 lecturer building at Universiti Tun Hussein Onn Malaysia (UTHM). Previous studies have lacked continuous monitoring and system-level differentiation, limiting insights into specific energy demands. In contrast, this study uses detailed energy audits, data logging, and visual inspections to assess lighting and air-conditioning performance based on Malaysian Standard MS1525. Findings reveal that air-conditioning dominates energy use, accounting for 94% of total consumption, while lighting contributes only 6%. Usage patterns align with occupancy and time of day, and several areas exhibit deviations from recommended lighting and HVAC conditions. These results highlight key opportunities for energy conservation measures such as HVAC system optimization, lighting controls, and improved insulation. The study provides practical guidance for improving energy efficiency in academic buildings and underscores the importance of room-level profiling in tropical climates.

1. Introduction

The energy sector of Malaysia is dependent on fossil fuels (oil, natural gas, and coal in particular). The nation is already a net exporter of oil, but it is projected that shortly in the next one or two decades; the country will shift into a net-consumer country of oil as a result of massive decline in national oil reserves and the sharp increase in energy demand. In Malaysia, the energy demand is anticipated to rise in the same ratio as the grain national product (GNP) [1]. The government of Malaysia has established high targets to achieve renewable energy (RE) penetration into the national energy system. Only around 2 percent of energy in Malaysia is renewable, however, there is an aim to rise to 20 percent by 2025 [2]. Alternative sources of energy like biomass, biogas, solar and wind power are also under consideration to vary the energy sources and make the energy generation less dependent on fossil fuels [3]. There are some challenges in the transition to renewable energy in Malaysia, the first of which is that the process of transition requires significant governmental support and the introduction of a regulatory framework that will enable integration of technology in the field of renewable energy [4]. Malaysia certainly possesses great potential in terms of renewable energy, especially in palm oil biomass, which would hold the country as a very nice state provider of renewable energy in the international map [3].

According to the Malaysia Energy Statistics Handbook 2020, the residential and commercial sectors accounted for 11.7% of energy consumption in Malaysia, while the transport sector consumed the most energy at 39.0% [5]. Buildings consume a large percentage of the global energy with a huge portion used up in heating, cooling and lighting. Buildings consume close to 48 percent of all the electricity that is used in Malaysia [6]. Other studies show that buildings in Malaysia consume 14.3% of total energy and 53 % of electric energy [7]. The Malaysian government has implemented different policies to support energy efficiency in operation and sustainability of buildings. These initiatives are crucial given that educational institutions contribute notably to energy demand due to their operational hours and occupancy patterns [8]. The consumption of energy in buildings of universities in Malaysia is a critical issue because it is a significant concern due to the increasing demand for consumption of electricity regarding the growing population of students as well as the enlargement of the facilities. Universities are large consumers of energy since the universities structures constitute approximately 11 percent of energy consumption in the commercial sphere [9]. In most countries, universities use more energy than any other government body and are thus energy intensive organisations [10]. They require high consumption of energy and water where electricity forms the major part [11]. Institutions of higher learning do have distinctive consume-patterns and features of energy-demand that have been rather less closely examined than other kinds of buildings. As an illustration, most of the energy use consumers include teaching rooms and administration rooms, where air conditioning consumes the largest quantity of energy [12]. Universities can be made more efficient in terms of energy-by-energy benchmarking. It is done by determining some type of a baseline, calculating energy performance of the building, and comparing the results with benchmarks [13].

In Malaysian universities, lecture facilities significantly contribute to overall energy consumption. This is primarily due to their operational requirements, which include lighting, heating, ventilation, and air conditioning (HVAC) systems, as well as the use of electronic devices during lectures. Lecture halls are among the most energy-intensive spaces within university campuses [14]. For instance, at Universiti Utara Malaysia (UUM), specific lecture halls such as the Accounting Faculty and FTM/DKG4 have been identified as having the highest electricity consumption. In 2018, the Accounting Faculty alone consumed approximately 1,802,412 kWh, translating to significant operational costs [15]. A substantial portion of energy in lecture facilities is used for cooling due to Malaysia's tropical climate. It is estimated that about two-thirds of the energy consumed in educational buildings is dedicated to cooling systems. This high demand for air conditioning is particularly pronounced during peak usage hours when classes are in session. The peak energy consumption typically occurs between 8 AM until 12 PM and 2 PM until 5 PM when lectures are actively taking place. This pattern highlights the importance of managing HVAC systems effectively during these hours to optimize energy use [16]. HVAC systems are typically the largest energy consumers in buildings. Their energy use is directly related to their operational costs [17]. Universities face unique challenges regarding energy consumption due to their diverse facilities and high occupancy levels. This sector often struggles with inefficiencies, particularly in HVAC systems and lighting [18]. Research indicates that Malaysian universities consume significant energy, often attributed to the high usage of air conditioning systems. For example, it was noted that two-thirds of the energy consumed by university buildings is for cooling purposes [19][20]. Factors influencing energy consumption, such as occupancy patterns, HVAC systems, and lighting systems. Occupancy patterns, which are variations in student attendance, can lead to fluctuating energy demands. Inefficient HVAC systems can lead to excessive energy use, especially in hot climates [18][20] while lighting systems are the type and efficiency of lighting significantly affect overall consumption.

While energy consumption is a significant concern for universities in Malaysia, research specifically focusing on the energy performance of lecture facilities remains limited. Existing studies often address broader aspects of university energy consumption, such as overall campus energy use, without delving into the specific energy demands and consumption patterns of lecture halls, classrooms, and seminar rooms. Research indicates that educational buildings in Malaysia consume approximately 11% more energy than other commercial buildings, primarily due to inefficient systems such as HVAC and lighting. This trend underscores the need for targeted studies on specific facilities like lecture halls and classrooms to understand their unique energy demands better [21]. This lack of in-depth analysis presents several challenges, such as without specific data on lecture facility energy consumption, it is difficult to accurately assess the magnitude of the problem and identify the most energy-intensive components within these spaces. A study conducted at the University of Malaya emphasizes that without detailed data on energy consumption patterns in lecture facilities, it is challenging to assess the magnitude of energy-related issues effectively. The absence of such data complicates the identification of high-energy-consuming components within these spaces, which is crucial for developing effective energy-saving strategies [22]. The absence of comprehensive data on lecture facility energy consumption also makes it challenging to establish benchmarks for energy performance and compare energy use across different universities or even within the same university. This limitation restricts the ability to identify the best practices and learn from successful energy-saving initiatives, which could lead to more efficient resource allocation and improved energy management strategies [23].

This study aims to conduct an in-depth energy performance analysis of a representative lecturer room within a public university in Malaysia. The primary objective is to comprehensively understand the building's energy consumption characteristics and identify key areas for improvement in energy efficiency. The research will involve detailed monitoring and analysis of the building's energy profile. This will include continuous monitoring of total energy consumption using data loggers, as well as the energy consumption of individual systems such as lighting, air-conditioning, and other electrical equipment, determining the periods of highest and lowest energy consumption, which will help identify opportunities for demand-side management strategies, and investigating the relationship between energy consumption and factors such as occupancy, ambient temperature, and time of day.

2. Methodology

A structured methodology ensures a comprehensive assessment of energy performance. The process involves a combination of preliminary and detailed audits, supported by strong data collection and analysis techniques. This initial phase, often referred to as a walk-through audit, provides a quick assessment of the building's energy consumption. Following the preliminary audit, a more in-depth analysis is conducted. This phase involves a thorough examination of the building's energy systems, including lighting and air conditioning.

2.1 Experimental Area and Equipment List

A walk-through audit was performed only on the C16 buildings (Lecturer Building) on the UTHM Parit Raja campus to determine the number of rooms and electrical components in each room. This study focused on one lecturer building (Block C16) that was selected on the basis of representativeness, uniformity, and functional identity with other lecturer buildings in the Universiti Tun Hussein Onn Malaysia (UTHM) campus. These buildings are designed, according to the same institutional standards, functioning on similar schedules and with similar occupancy patterns and exposure to the environment. Moreover, lecturer buildings at UTHM are mainly administrative and academic staff facilities, and room arrangement is similar, i.e. individual lecturer offices, meeting rooms, corridors, and shared spaces all furnished with similar lighting and air-conditioning systems. Consequently, the observed energy consumption features of Block C16 are deemed to reflect those of other lecturer buildings within campus.

The Development and Maintenance Office (PPP) also provided architectural plans for the structures and appliance requirements. Energy consumption data were collected using a three-phase energy data logger installed on a main distribution board (DB) serving the lecturer rooms in Block C16. The data logger was configured to continuously record electrical parameters such as voltage, current, real power, and the energy consumed over specific time intervals during the entire process of the monitoring. The distribution board level installation also enabled the proper capture of electrical loads aggregated to major end-use systems, especially lighting and air-conditioning.

The data logging process was conducted over a five-day period during a semester break to minimize the effects of irregular occupancy and to establish baseline operational energy patterns. Measurements were recorded continuously for both working hours (7:00 AM–7:00 PM) and non-working hours (7:00 PM–7:00 AM), allowing clear differentiation between occupied and non-occupied energy usage profiles. This approach also enabled comparison of energy consumption between the air-conditioning and lighting systems. Furthermore, data loggers were gathered during a semester break. The semester break period was selected as it represents one of the most significant variations in annual energy consumption patterns for the C16 building. All collected data were subsequently recorded, analysed, and classified by system type for energy profiling and load apportioning analysis.

Good lighting for the comfort of the building's occupants and supporting several activities depends mostly on the lighting system. Energy consumption is largely influenced by the lighting choices. Only light-emitting diode (LED) lighting, with three distinct power ratings as indicated in Table 1, is utilized in the C16 building. An air conditioning system is essential in any facility to keep users comfortable. This air conditioning system regulates the temperature and humidity of the air in the building by collecting heat from the internal air and releasing it to the outside. The C16 building uses two types of air conditioning, as illustrated in Table 2.

Table 1 *The area in the C16 building uses a specific type of lighting*

Lighting Types	Power Rated (Watt)	Area
Circle Shape LED	18	Ground Floor Lobby
Single LED	18	Hallway, 1st Floor Lobby
Double LED	20	Inquiry Desk, Office, Meeting Room, Lecturer Room

Table 2 *The area in the C16 building uses a specific type of air conditioning*

Air-conditioning Types	Power Rated (HP)	Area
Wall Mounted	1.0	Inquiry Desk, Office Room 1, Meeting Room, Lecturer Room
Ceiling Mounted	1.5	Ground Floor Lobby, 1st Floor Lobby, Office Room 2

2.2 Measurement Equipment

The description of the listed measurement equipment is explained in the following Table 3. Electrical measurements in this paper were performed with Metrel ME435 (Three-phase energy logger) handheld power quality analyser and energy logger. This device can measure the important electrical quantities such as current and voltage, power factor, harmonics, real power, and reactive power in three-phase systems. It is characterized by a high sampling rate of up to 8,000 samples per second, which provides the ability to perform the analysis of electrical load changes in detail and with great accuracy. The device has a display screen of 3.5 inches TFT which gives clear visualisation of data on site during measurements. In current sensing and electrical connectivity, the analyser employs Rogowski coils, which are characterized by the presence of flexible-coloured loops, as well as alligator clips. All the measurement data obtained are recorded in a 4 GB SD card to be later retrieved and analyzed in detail.

The light measurements were performed on a Testo 540 digital light meter (Lux meter). This is a small, entry-level lux meter that is intended to measure the lighting conditions in an indoor setup like the workplace, office, and commercial areas. The sensor is adjusted to the spectral sensitivity of the human eye, so that perceived illuminance would be accurately measured. The instrument is versatile and can be used in low- and high-lighting conditions with the measurement range of 0-99,999 lux. Other important characteristics of the device are a hold facility where readings can be frozen to be recorded easily and also a display facility where the minimum and maximum illuminance values can be captured during periods of measurement.

The carbon monoxide concentration was measured through a Smart Sensor ST9700 carbon monoxide meter (Anemometer), or a handheld CO gas detector. The gadget is intended to continuously monitor the level of carbon monoxide in the immediate environment to maintain the quality of indoor air and the safety of occupants. It comes with a high-definition backlit display, which enables easy and clear reading of measurement results. An audible and visual alarm system is also part of the meter, which is automatically triggered when the amount of carbon monoxide in the air rises to a predetermined level. Besides, the device is capable of high-precision measurements with a broad detection limit of 0-1000 ppm and is ideal to use in the field of indoor environmental monitoring.

Table 3 *Description of the listed measurement equipment*

No	Equipment Type	Function
1	Three-phase energy logger 	To perform power measurement at DBs
2	Lux meter 	To measure lighting lux level
3	Anemometer 	To determine wind speed or air velocity

3. Results and Discussion

Block C16 is considered representative of other lecturer buildings at UTHM due to its standardized design, consistent functional usage, similar environmental exposure, and practical accessibility for data collection. These characteristics make it a valid model for benchmarking and proposing improvements applicable to other similar academic structures within the university for energy performance analysis.

Although the main incoming energy profile is typically provided, access to the main incoming supply was restricted; therefore, it was not included, as this paper primarily focuses on the lighting and air-conditioning systems.

3.1 Energy Profile for Lighting System

Figure 1 presents the electricity usage (in kW) over three days (21 August 2024–23 August 2024). Three days of logging lighting usage can give a good basic to study daily profile for typical usage, but for comprehensive energy audits or understanding peak demand/variability (especially for efficiency improvements), guidelines often recommend 7 days or more to capture as per Energy Audit Guidelines. These guidelines suggest using appropriate data loggers to record building and end-use load cycles, with typical daily load profiles of main incoming for seven (7) days, one (1) to seven (7) days for HVAC system and one (1) hour to one (1) day for other equipments [31].

Morning rise with a noticeable increase in electricity usage, peaking around 0.215 kW on 21 August. This coincides with the start of working hours when lights are turned on for occupancy. After the initial peak, usage gradually declines but remains relatively high, with minor fluctuations. This suggests ongoing activity and lighting use in the building. As the day ends, there's a clear downward trend, with usage dropping to its lowest point (around 0.185 kW) on 21 August. This likely reflects reduced occupancy and lights being turned off after hours. During late-night and early-morning hours, the load stabilizes at its minimum, indicating only essential lighting remains on.

The lowest observed electricity usage is 0.185 kW. This represents the base load, the minimum power required to keep essential lighting, such as emergency, security, or hallway lights, operational when the building is mostly unoccupied. The base load is consistent across all three days, showing that this minimum demand is independent of day-to-day activity and tied to building safety or operational requirements.

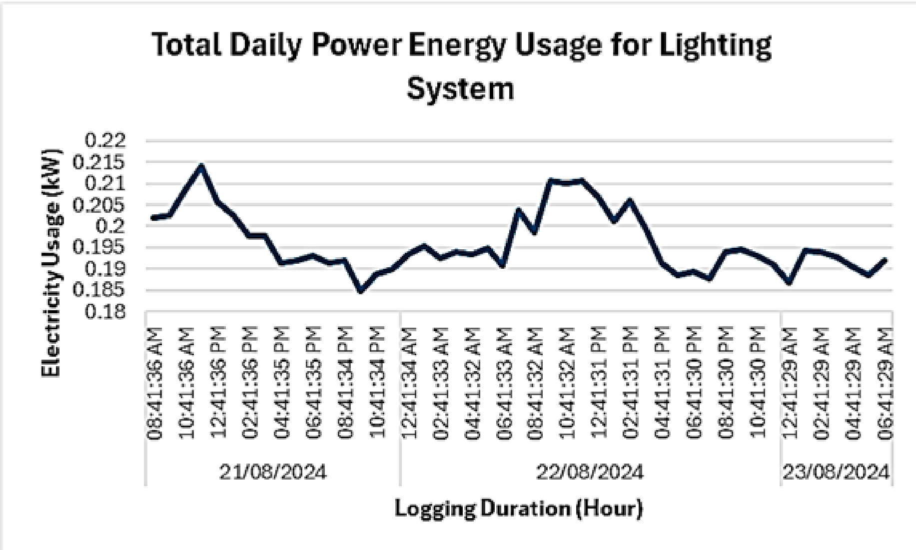

Fig. 1 *Total daily power energy usage for lighting system throughout the three-day logging duration*

The graph in Figure 2 shows electricity usage fluctuates between roughly 0.19 kW and 0.215 kW during working hours across two days (21 August–22 August 2024). Two days of logging lighting usage can give a good basic to study daily profile for typical usage, but for comprehensive energy audits or understanding peak demand/variability (especially for efficiency improvements), guidelines often recommend 7 days or more to capture as per Energy Audit Guidelines. These guidelines suggest using appropriate data loggers to record building and end-use load cycles, with typical daily load profiles of main incoming for seven (7) days, one (1) to seven (7) days for HVAC system and one (1) hour to one (1) day for other equipments [31].

There are clear peaks above 0.21 kW, especially in the late morning and early afternoon. The load is variable, reflecting changes in occupancy, daylight, and perhaps operational schedules. Most values are above 0.20 kW, indicating increased lighting demand when the building is occupied.

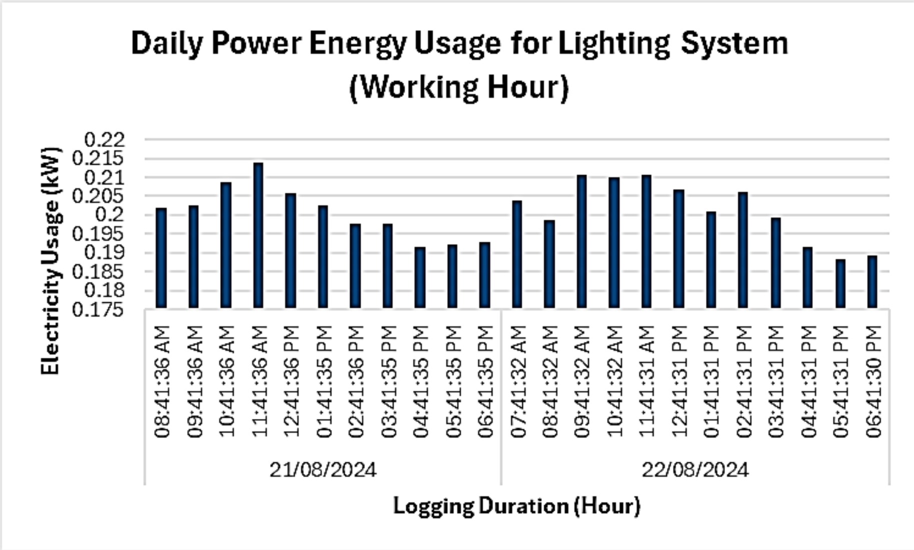

Fig. 2 *Daily power energy usage for the lighting system (working hour) throughout the two-day logging duration*

Figure 3 shows electricity usage between 0.184 kW and 0.194 kW during non-working hours (evenings, nights, and early mornings). The load is more stable and consistently lower than during working hours. Minor fluctuations may be due to scheduled security or emergency lighting checks, but overall, the pattern is flat. Most values cluster around 0.186–0.192 kW. The highest consumption occurs around 09:41:30 PM, reaching approximately 0.196 kW. This is because the lighting system continues to operate at a relatively high level immediately after the working hour ends. The building may still have some occupants during the early evening hours, such as staff working late or students studying. This could explain the initial high consumption. After the initial peak, the power consumption gradually decreases throughout the night, reaching the lowest point around 12:41:29 AM.

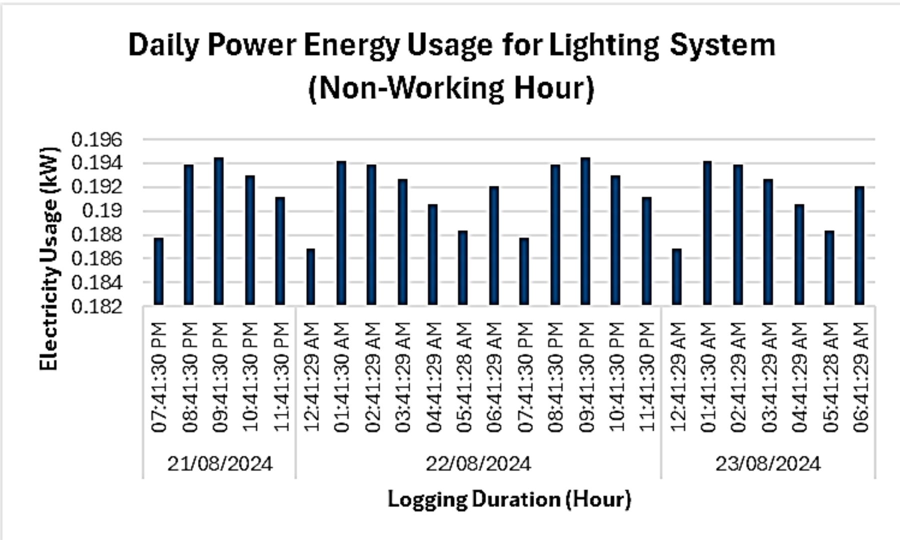

Fig. 3 *Daily power energy usage for the lighting system (non-working hour) throughout the three-day logging duration*

The base load is the minimum level of demand that occurs regardless of occupancy or activity-typically due to essential or safety lighting. The lowest observed values (around 0.184 kW) during non-working hours represent the base load. This load is present every night, indicating it is not influenced by daily activity and is likely due to emergency, exit, or security lighting.

3.2 Energy Profile for Air-Conditioning System

Figure 4 presents a detailed view of the air-conditioning system's power consumption pattern over a specific logging duration from 19 August (7.00 A.M) until 21 August (7.00 A.M). Three days of logging air-conditioning usage can give a good basic to study daily profile for typical usage, but for comprehensive energy audits or understanding peak demand/variability (especially for efficiency improvements), guidelines often recommend 7 days or more to capture as per Energy Audit Guidelines. These guidelines suggest using appropriate data loggers to record building and end-use load cycles, with typical daily load profiles of main incoming for seven (7) days, one (1) to seven (7) days for HVAC system and one (1) hour to one (1) day for other equipments [31].

On August 19, the load starts at around 22 kW, quickly spikes to nearly 27 kW (likely as the system starts up and the building is cooled for occupancy), then rapidly declines. After the initial peak, consumption drops sharply to a low range of 2–3 kW and stays there through the night and early morning. On August 20, a similar pattern emerges a sharp increase in the morning (around 7 AM), peaking at about 18–20 kW, then gradually declining through the afternoon, and dropping back to the low overnight base. During late-night and early-morning hours on both days, the load remains consistently low, reflecting minimal or no cooling demand. The base load is the lowest sustained demand, visible during late-night and early-morning hours, consistently at 2–3 kW.

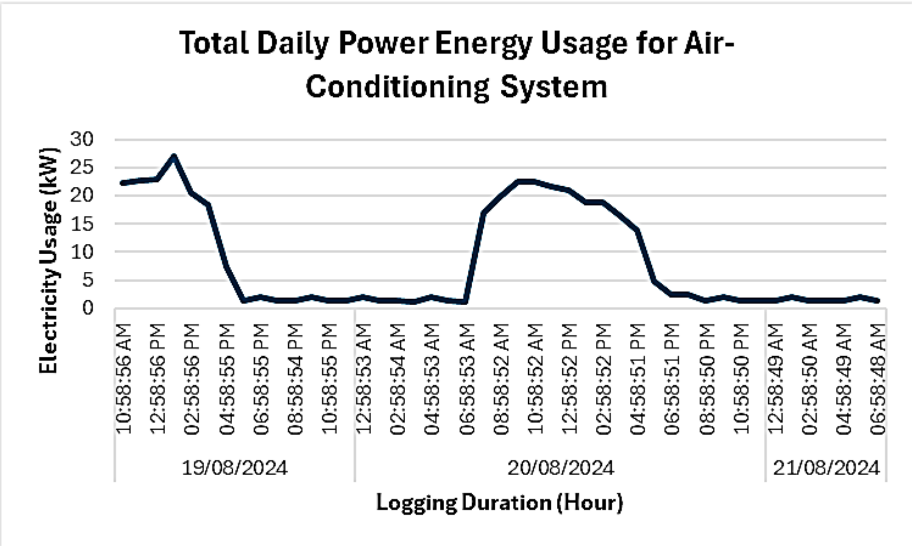

Fig. 4 *Total daily power energy usage for air-conditioning system throughout the three-day logging duration*

The graph in Figure 5 shows daily power energy usage for the air-conditioning system (working hours) throughout the two-day logging duration. Two days of logging air-conditioning usage can give a good basic to study daily profile for typical usage, but for comprehensive energy audits or understanding peak demand/variability (especially for efficiency improvements), guidelines often recommend 7 days or more to capture as per Energy Audit Guidelines. These guidelines suggest using appropriate data loggers to record building and end-use load cycles, with typical daily load profiles of main incoming for seven (7) days, one (1) to seven (7) days for HVAC system and one (1) hour to one (1) day for other equipments [31].

During working hours (daytime), electricity usage for the air-conditioning system fluctuates between about 10 kW and 25 kW, with occasional peaks reaching just above 25 kW. There is a sharp increase in load at the beginning of each workday, likely due to the system cooling down the building after a period of inactivity. Loads remain high through midday and early afternoon, reflecting peak occupancy and the hottest part of the day. There is a gradual decrease in load toward the end of the working period as occupancy drops or outside temperatures cool. The load fluctuates but generally stays above 10 kW during working hours.

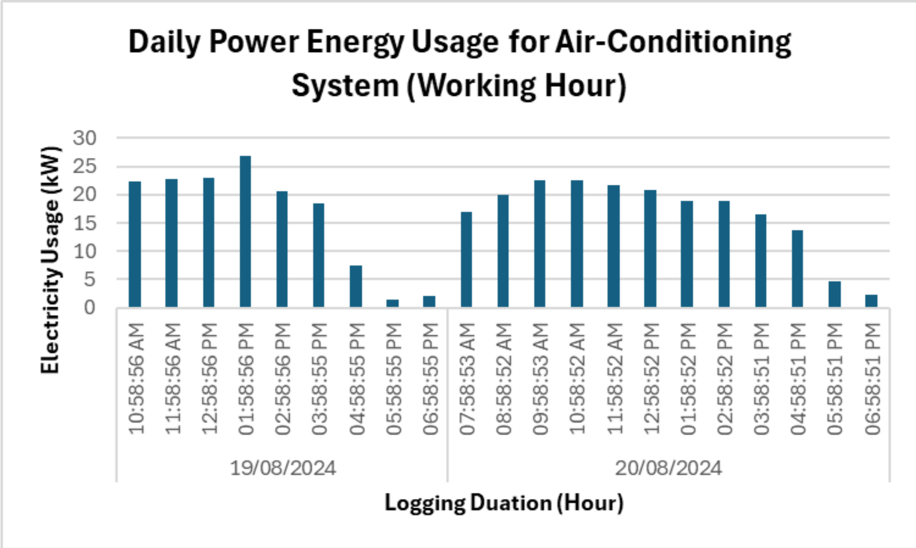

Fig. 5 *Daily power energy usage for the air-conditioning system (working hour) throughout the two-day logging duration*

The Figure 6 shows that during non-working hours (evenings, nights, early mornings), electricity usage drops significantly, fluctuating between about 1.2 kW and 2.2 kW. Loads are much lower and more stable, with minor fluctuations possibly due to periodic cycling for humidity control, equipment rooms, or minimal ventilation. There are no significant spikes, indicating most cooling equipment is off or running at minimal settings. The highest consumption occurs around 07:58:50 PM, reaching approximately 2.37 kW. This is because the air-conditioning system continues to operate at a relatively high level immediately after the peak hours end. After the initial peak, the power consumption gradually decreases throughout the night, reaching the lowest point around 06:58:48 AM. The building may still retain some heat from the day, necessitating continued cooling during the early evening hours. This could explain the initial high consumption. If there are evening events or activities in the building, the air-conditioning system might need to operate at a higher level to maintain comfortable conditions. The settings of the air-conditioning system, such as temperature setpoints and fan speeds, can influence energy consumption during non-working hours. The base load is the lowest consistent level of demand, observed during non-working hours around 1.2–1.5 kW.

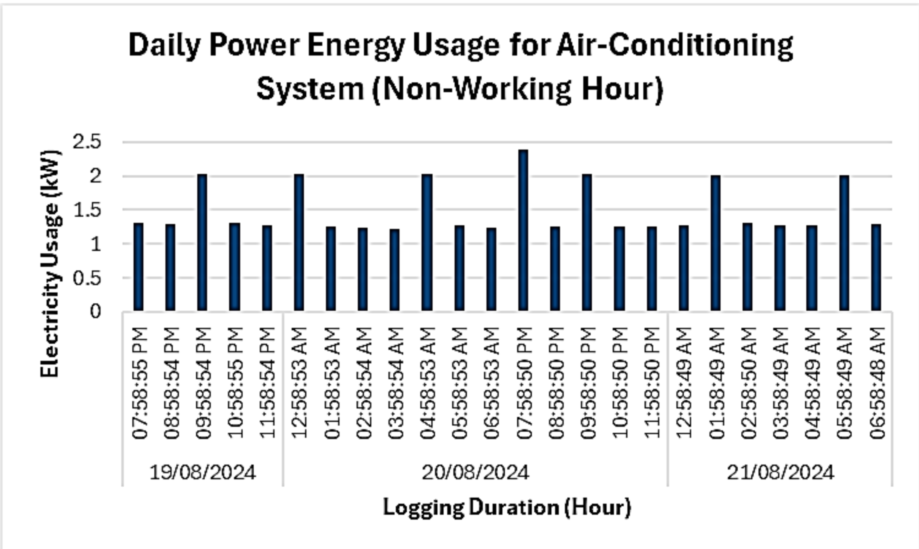

Fig. 6 *Daily power energy usage for the lighting system (non-working hour) throughout the three-day logging duration*

3.3 Load Apportioning

This part describes the findings and analysis of building load apportioning for the lecturer room of the C16 Building. Understanding how the load apportioning energy consumption is divided among various electrical systems is essential for identifying significant areas of energy use, optimizing efficiency, and targeting energy-saving measures. To achieve this, the study measured the energy consumption of the building's major electrical systems, specifically the lighting system and the air-conditioning system, which are typically the primary contributors to energy use in institutional buildings. Figure 7 is a pie chart, a graphical tool that visually displays the proportional contributions of different categories to a whole. In this case, the pie chart illustrates the percentage share of energy consumption attributed to the two main systems, such as air conditioning and lighting.

The pie chart shows that 94% of the total measured electrical load, equivalent to 389.47337 kW, is consumed by the air-conditioning system. This overwhelming majority highlights that air conditioning is the dominant energy consumer in the lecturer room. This is consistent with typical building energy profiles in tropical climates like Malaysia, where cooling demands are high due to hot and humid weather conditions. The high energy consumption by air conditioning underscores the importance of focusing energy efficiency efforts on HVAC systems to achieve significant reductions in overall energy use.

The lighting system accounts for only 6% of the total load, which translates to 23.195 kW. This smaller proportion reflects the relatively lower power demand of LED lighting systems, which are energy-efficient compared to traditional lighting technologies. However, it is important to note that the estimated daily operation hours for lighting are assumed to be 9 hours. This may underestimate actual usage, as some lighting fixtures might operate 24 hours a day for security or operational reasons. Despite this, lighting remains a minor contributor to overall energy consumption compared to air conditioning.

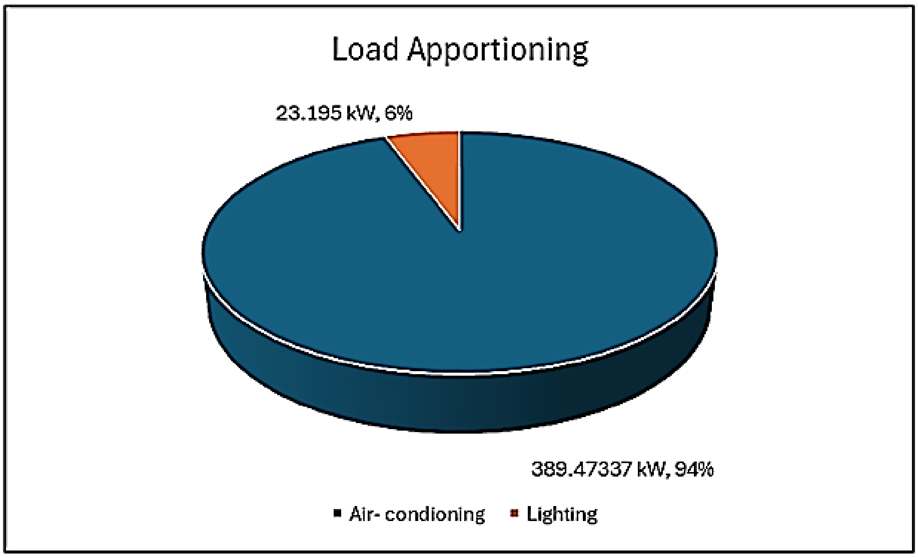

Fig. 7 *Energy load apportioning for the lecturer room of the C16 building*

3.4 Visual Inspection

The study conducted on energy performance in lecturer rooms at a public university revealed several findings through visual inspection. The inspection showed that only LED lighting was installed and used across various areas. LED lighting is widely recognized for its superior energy efficiency, longer lifespan, and lower heat output compared to traditional incandescent or fluorescent lighting. This choice reflects a commitment to sustainable energy use and aligns with modern energy-saving practices. The Malaysian Standard MS1525 provides recommended illuminance (lux) levels for various indoor environments to ensure adequate visibility, safety, and comfort while minimizing energy use. The study measured lux values in different areas were compared against these standards based on the data provided in Table 4. Hallways D and E have measured lux values of 71 and 70. The recommended lux approximately 100 lux for safe and comfortable passage. The staff room with the measured lux is 414, within the recommended range of 300 to 400 lux for general tasks and collaborative work. The lighting level in the staff room slightly exceeds the upper recommended limit but remains within an acceptable range. This level is appropriate for a variety of activities including reading, discussions, and computer work, providing a bright and comfortable environment. The measured lux is 373 for office room 1, within the recommended range of 300 to 400 lux for typical office tasks such as reading, writing, and computer use. The measured illuminance is well within the recommended range, indicating that the lighting is suitable for productive office work without causing eye strain or excessive glare. While the measured lux is 108 for the first-floor lobby, within the recommended lux approximately 100 lux for wayfinding and general circulation. The lighting in the first-floor lobby meets the recommended levels, ensuring sufficient visibility for occupants to navigate safely and comfortably through space.

Table 4 *Comparison of luminance for block C16 in UTHM*

Areas	Average Lux (Measured)	Lux Level (MS1525)	Remark
Ground Floor Lobby	254	100	Over Lit
Inquiry Desk	465	300	Under Lit
Toilet	184	100	Over Lit
Hallway D	71	100	Ok
Hallway E	70	100	Ok
Office Room 2	164	300-400	Under Lit
Staff Room	414	300-400	Ok
Office Room 1	373	300-400	Ok
First Floor Stair	24	100	Under Lit
First Floor Lobby	108	100	Ok
Hallway K	52	100	Under Lit
Executive Meeting Room	433	300-400	Over Lit
Hallway M	47	100	Over Lit
Main Meeting Room	252	300-400	Under Lit

The visual inspection highlighted that air conditioning systems were significant contributors to electricity consumption. It was noted that two-thirds of the energy consumed in educational buildings was dedicated to cooling, emphasizing the need for efficient management of these systems during peak hours [18][19]. For the purpose of engineering design, room comfort conditions should consider the following three main factors such as dry bulb temperature, relative humidity, and air movement (air velocity). The indoor design conditions of an air-conditioned space for comfort cooling should follow MS1525 standards established by the Department of Standards Malaysia.

The findings from the visual inspection of the air conditioning system at the public university, as shown in Table 5, provide understandings into the indoor thermal environment and the effectiveness of the HVAC system in maintaining comfortable conditions. The temperature measurements taken at different locations within the building-including the Ground Floor Lobby, Inquiry Desk, Office Rooms, Meeting Rooms, and other spaces, show a temperature range from 24.6°C to 25.1°C. This relatively tight range show that the air conditioning system is performing consistently and maintaining a stable indoor climate throughout the facility. The Malaysian Standard MS1525 recommends a design dry bulb temperature range of 24°C to 26°C for indoor environments. This range is designed to balance occupant comfort with energy efficiency, ensuring that the indoor temperature is neither too warm nor too cold. The Industry Code of Practice (ICOP) 2010, established by the Department of Occupational Safety and Health (DOSH) Malaysia, sets an acceptable air temperature range of 23°C to 26°C for workplace environments. This slightly broader range accommodates variations in building use and occupant preferences while maintaining safe and comfortable conditions.

The air velocity measurements taken within the building's air distribution system show a significant variation, ranging from 0.87 m/s to 2.10 m/s. This wide range shows that air movement is not uniform throughout the space, which can have important implications for occupant comfort and system performance. The Malaysian Standard MS1525 recommends an air movement range of 0.15 m/s to 0.50 m/s for indoor environments. Areas where air velocity approaches or exceeds 2.10 m/s are experiencing relatively strong air movement. While some air movement is essential for effective cooling and ventilation, excessively high air velocity can lead to draftiness, a sensation of cold or uncomfortable wind blowing on occupants. This can cause discomfort, especially if the airflow is directed at seating or working areas, potentially leading to complaints or reduced productivity. Even the lower measured velocity of 0.87 m/s is still above the recommended range, but comparatively less intense than 2.10 m/s. However, if there are zones with air velocity closer to or below 0.15 m/s (not observed here but possible in some areas), it could result in stagnant air pockets. Stagnant air reduces the effectiveness of cooling, causes uneven temperature distribution, and can lead to poor indoor air quality due to inadequate ventilation.

The relative humidity readings remain relatively consistent across different areas, ranging from 69.9% to 71.0% are slightly above the recommended design range according to MS1525 standards, which is 50% to 70%. Similarly, the ICOP 2010 guidelines by DOSH Malaysia specify an acceptable RH range of 40% to 70% [23]. Maintaining appropriate humidity levels is important for occupant comfort and preventing issues like mold growth. However, the MS1525 and ICOP guidelines allow up to 70%, which likely considers specific local climate and building conditions.

Table 5 *Air conditioning data*

Areas	Temperature (°C)	Air Velocity (m/s)	Relative Humidity (%)
Ground Floor Lobby	24.7	0.88	71.0
Inquiry Desk	24.7	2.06	69.9
Office Room 2	24.6	2.10	70.1
Staff Room	24.6	2.09	69.9
Office Room 1	24.8	0.89	70.9
First Floor Stair	25.1	0.87	70.9
Executive Meeting Room	24.6	2.09	70.1
Main Meeting Room	24.9	2.07	70.3

3.5 Energy Conservation Measures (ECMs)

Since air conditioning dominates 94% of energy use, energy conservation measures can be classified into no-cost/low-cost measures. Energy conservation measures targeting HVAC systems, such as improving insulation, implementing smart controls, and regular maintenance, will have the greatest impact on reducing overall energy consumption. Inspecting and sealing gaps around windows, doors, and any penetration in walls and ceilings using caulk, weather stripping, or expanding foam. This prevents conditioned air from escaping and unconditioned air from entering, reducing the AC load. Dirty filters restrict airflow, making the AC unit work harder and less efficiently. Following the manufacturer's recommendations for cleaning or replacing filters is important. Regularly checking for any obvious issues like unusual noises, leaks, or excessive dust buildup. Although lighting contributes less, continued use of energy-efficient LED lighting and optimized lighting controls, such as occupancy sensors and daylight harvesting, can still provide meaningful energy savings. Installing occupancy sensors in areas with intermittent use (hallways) ensures lights are only on when needed and opening blinds and curtains during the day to utilize natural light and reduce the need for artificial lighting.

4. Conclusions

In conclusion, the study focuses on the energy performance analysis of lecturer rooms in public universities, particularly the C16 building at Universiti Tun Hussein Onn Malaysia (UTHM). The findings include that air conditioning is the primary electricity consumer, accounting for 94% of total energy use, largely due to Malaysia's tropical climate and the need for cooling during peak occupancy hours. Although lighting systems contribute a smaller percentage of energy use (6%), optimization opportunities exist through better control systems and efficient fixtures. Peak electricity consumption coincides with high occupancy during working hours and extreme weather. A cyclical energy usage pattern highlights opportunities for demand-side management. Energy profiling revealed actionable opportunities for reducing energy waste, such as improving air-conditioning systems and controlling off-peak electricity use. Visual inspections show some areas meet the MS1525 lighting and cooling standards, while others show over- or under-lit conditions and potential inefficiencies. The study concludes that understanding specific energy performance analysis in lecturer room is essential for developing targeted strategies for energy efficiency improvements and sustainability in educational institutions.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors are responsible for the study conception, research design, data collection, data analysis, result interpretation and manuscript drafting.

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