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Electrical Energy Audit at Selected Laboratory of Faculty of Technical and Vocational Education (FPTV) of Universiti Tun Hussein Onn Malaysia

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Abstract: An electrical energy audit is a thorough analysis of a building's electrical system to identify inefficiencies and cost-saving opportunities. This paper presents an audit conducted on block C of the FPTV building at UTHM. The objectives of the work include measurements, load profile analysis, energy cost calculations, and proposing Energy Saving Measures (ESMs) based on the findings. The study addresses the issue of excessive electricity consumption at UTHM, compliance with national standards (MS1525:2014). The audit involved a comprehensive assessment, floor drawings, laboratory measurements, illuminance analysis, temperature and humidity evaluation, and data analysis. The study highlights illuminance levels in laboratories and the need for energy-saving measures. The Electrical Technology and Power Supply Labs meet or slightly fall below the recommended illuminance level, while the Building and Surveying Services Lab exceeds it due to natural light. The Micro Teaching Lab significantly surpasses the recommended level with artificial and natural lighting. Maintaining a temperature range of 23°C to 25°C is advised for energy efficiency and user comfort. Humidity levels are generally acceptable, except in the electronic lab where high humidity can cause equipment overheating. The study compares power consumption during physical and online class sessions, showing higher energy usage in physical sessions due to energy-intensive components. Energy-saving measures are categorized as no-cost and mid-cost measures, including behavioral changes, equipment usage reduction, de-lamping, and LED implementation. Implementing the suggested Energy Saving Measures can optimize energy usage, reduce waste, and potentially save money. The research findings contribute to promoting sustainable energy practices in educational institutions, with recommendations for future research to expand the scope and assess specific systems and utilities.

Keywords: Electrical Energy Audit, Energy Saving Measures (Esms), No-Cost Measures, Mid-Cost Measures

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1. Introduction

Energy auditing is known as the verification, monitoring and analysis of use of energy followed by submission of technical report containing recommendation for improving energy efficiency with cost benefit analysis and an action plan to reduce energy consumption. Basically, an energy audit is conducted by an energy auditor and involves a detailed building inspection and analysis of how efficiently energy is being used [1]. For the purposes of heating, cooling, lighting, and technological devices like computers, buildings use a lot of energy. According to earlier studies, the building will use between 40% and 50% of its energy consumption. The lighting, on the other hand, uses about 13% of the energy, and this rate of energy consumption is rising [2]. Therefore, it is important to use this energy wisely and to refrain from using it excessively, which could lead to energy instability for other users. Effective use of energy resources can result in a variety of advantages, including the ability to reduce energy consumption and avoid making unnecessary expenditures.

Additionally, in enhancing energy efficiency. It can reduce the impact of pollution and greenhouse gas emissions and help to stabilize the cost of the average monthly electricity bill [3]. There are various strategies potential to be adopted to promote green aspects in building sector includes; showcase energy efficient buildings, public awareness campaigns, incentives on less energy consumption, use of efficient appliances thus targeting general public and private sector with pulling strategy [4].

The electrical system, humidity, and temperature in the building are the primary focuses of the Walk-through Electrical Energy Audit that is being conducted for the building that houses the Faculty of Technical and Vocational Education (FPTV). The optimization of energy consumption may directly benefit the university, power plants, and industrial facilities that are participating in this initiative, which can assist lower total costs. Therefore, it is strongly suggested that people make use of electrical equipment that is both efficient and have qualities that enable them to conserve power.

2. Methodology

The work involves several steps. It begins with selecting a building based on prior consultation with a supervisor. A literature review is then conducted to summarize previous research on electrical energy audits, identifying trends, gaps, and contradictions. A letter is written to the deputy dean to request permission for an audit of the Faculty of Technical and Vocational Education (FPTV) building. During the audit, temperature, humidity, and thermal energy output readings are taken and evaluated. An analysis is conducted using MS1525:2014 as a benchmark, and if the results don't meet regulatory requirements, adjustments are suggested to align with the standard. Energy-saving measures are proposed to reduce energy consumption and associated costs, thereby minimizing the facility's environmental impact. Figure 1 depicts the flowchart of the work.

A. Building selection

The energy audit focuses on Block C of the Faculty of Technical and Vocational Education (FPTV) at Universiti Tun Hussein Onn Malaysia. The block consists of three floors which are ground floor, first floor, and second floor.

B. List of measuring equipment

The energy audit utilizes several measuring devices for data collection. The equipment includes a lux meter, a humidity and temperature sensor, and a thermal imager camera.

The lux meter used is the UT380 series luminometer, specifically models UT381 and UT382. It is a digital meter with a high-precision visible light sensor and a microprocessor for data processing. The meter measures illuminance, which is the luminous flux received per unit area, in both lux and foot candles. The accuracy tolerance varies based on the range being measured. The UT382 model can be connected to a PC for real-time data storage and analysis.

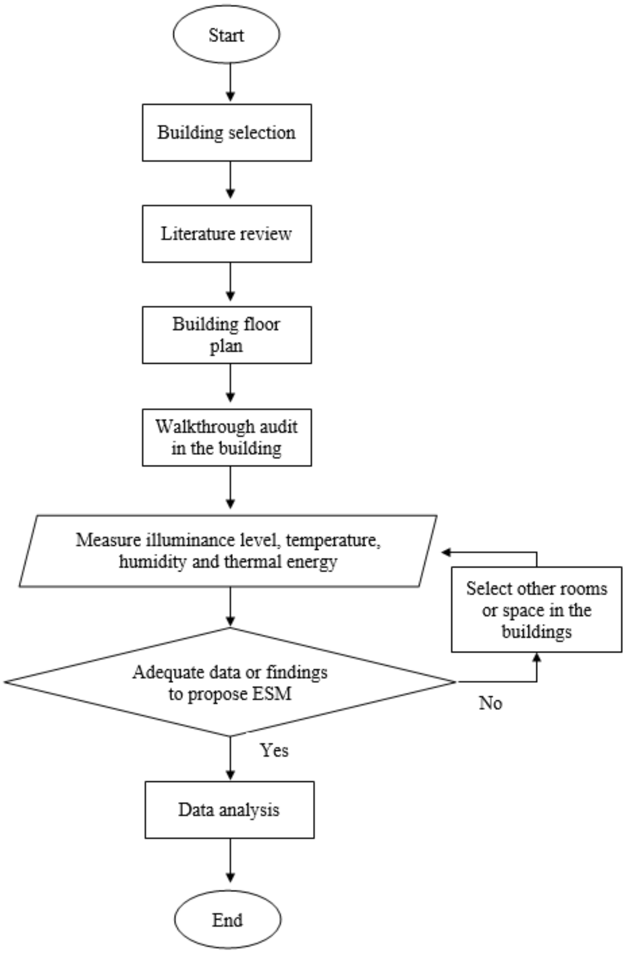

Figure 1: Flowchart of the work

The humidity and temperature sensor used is the UT330-USB series USB datalogger. It features high-precision sensors for temperature, humidity, and atmospheric pressure. The datalogger has an IP67 rating for water and dustproof protection and can store up to 60,000 sets of data. It can be connected to a PC via USB for data transmission and is suitable for monitoring sensitive goods during transportation and storage.

Table 1 listed the comparison in terms of performance between lamps and Light-Emitting Diode (LED).

Table 1: Comparison between Led tubes and fluorescent tube

Characteristics	Led tubes	Fluorescent tube
Average source lifespan	50,000 hours	30,000 hours
Heat output	Not cause heat build-up	Up to 2 degrees warmer
Efficiency	More efficient	Less efficient
Material	Does not contain hazardous metals or mercury	Does contain mercury and phosphor
Brightness	2000 luminance	2000 luminance
Power consumption	18 watts	36 watts
Luminous efficacy	100 luminance/watts	56 luminance/watts

3. Results and Discussion

3.1 Results and discussion for lux measurement

The recorded illuminance levels in the different laboratories indicate the amount of lux level present in each area. The lux measurement has been done following this procedure of operation of the lux meter:

i) Switch on the lux meter.
ii) Measure the lux at 1-meter height from ground level.
iii) Hold the light sensor facing towards the light.
iv) The display shows the lux value.
v) Monitoring the lux value.
vi) Records the readings.

To determine the lux levels at various locations, the lux measuring technique was carried out in selected laboratories. This method allowed for a thorough evaluation of the lighting in the laboratories and offered useful information for assessing the illuminance levels across the rooms.

Electrical Technology Laboratory

In this Electrical Technology Laboratory, there are nine different locations where the illuminance level test had been carried out. Table 2 contains the results of the illuminance level measurements taken for each individual part.

Table 2: Recorded illuminance level of Electrical Technology Laboratory

Place number	Illuminance level (Lux)	MS 1525:2014
1	572	
2	593	
3	590	
4	511	
5	488	500
6	440	
7	530	
8	587	
9	558	

This laboratory's illuminance levels vary from 440 to 593 Lux. The majority of the measured areas are within or close to the MS 1525:2014 recommended illuminance level of 500 Lux.

Electrical Power Supply Laboratory

The illuminance level test was performed in three separate places in this Electrical Power Supply Laboratory. The results of the illuminance level measurements for each individual component are shown in Table 3.

Table 3: Recorded illuminance level of Electrical Power Supply Laboratory

Place number	Illuminance level (Lux)	MS 1525:2014
1	506	
2	449	500
3	479	

This laboratory's illuminance levels vary from 449 to 506 Lux. The measured areas, like those at the Electrical Technology Laboratory, are often near to or slightly below the recommended illuminance level of 500 Lux. Because the lux number is significant to use, it can be assumed that the lighting level in this space is in good condition.

Building and Surveying Services Laboratory

The illuminance level test was performed in three separate places in this Building and Surveying Services Laboratory. The results of the illuminance level measurements for each individual space are shown in Table 4.

Table 4: Recorded illuminance level of Building and Surveying Services Laboratory

Place number	Illuminance level (Lux)	MS 1525:2014
1	567	
2	577	500
3	737	

This laboratory's illuminance levels vary from 567 Lux to 737 Lux. This laboratory's measured regions all surpass the recommended illuminance level of 500 Lux. The existence of an opening part at the back of the room, enabling more natural light to enter, may be responsible for the increased illuminance levels.

Micro Teaching Lab

The illuminance level test was carried out in six different spots across this Micro Teaching Lab. Table 5 displays the results of the illuminance level measurements for each separate spot.

Table 5: Recorded illuminance level of Micro Teaching Lab

Place number	Illuminance level (Lux)	MS 1525:2014
1	827	
2	897	
3	1181	500
4	881	
5	676	
6	710	

This laboratory's illuminance levels range from 676 Lux to 1181 Lux. In this laboratory, all measured regions much surpass the recommended illuminance level of 500 Lux. Both artificial lighting (25x3 T8 fluorescent tube lighting) and natural light from the windows contribute to the high illuminance levels.

3.2 Results and discussion for temperature and humidity measurement

The temperature and humidity measurement were conducted using the USB datalogger which placed in the room studied. It had been placed on top of the tall cabinet in the room to record the temperature. The temperature and humidity were recorded within 24 hours to collect the data in day and night. The results as shown in Figure 2 to Figure 7.

Based on the information that has been gathered, the average of temperature in all room were in good conditions which is between 23°C and 25°C.

In the context of humidity measurement, except the electronic laboratory as shown in Figure 8, where the average humidity level exceeds the requirements by 2.82% in total, the humidity levels in those rooms observed were in acceptable condition. High humidity levels of more over 70% can promote mold and mildew growth, resulting in rusting and corrosion, short circuits, and overheating.

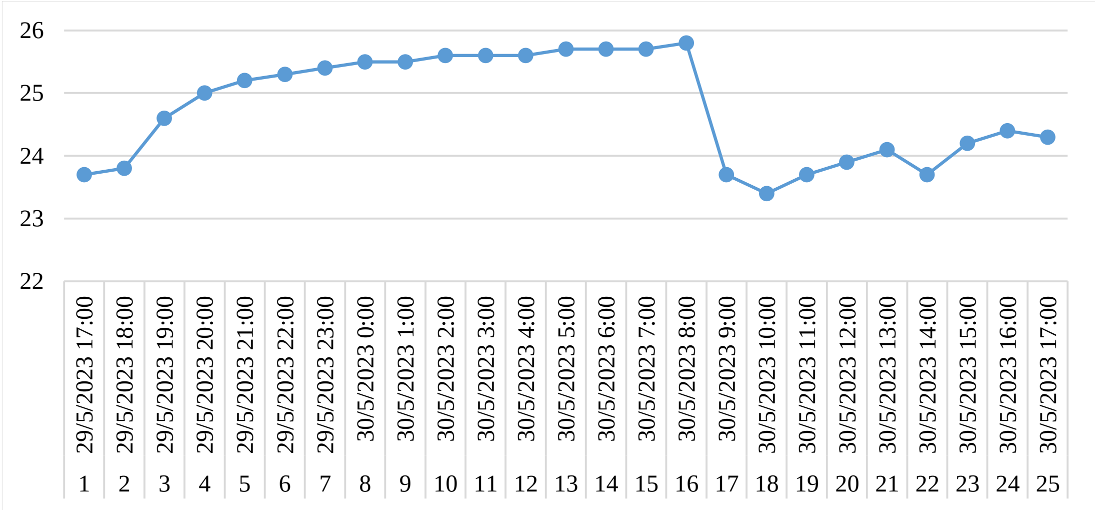

Figure 2: Graph for temperature in Electronic Laboratory in 24 hours

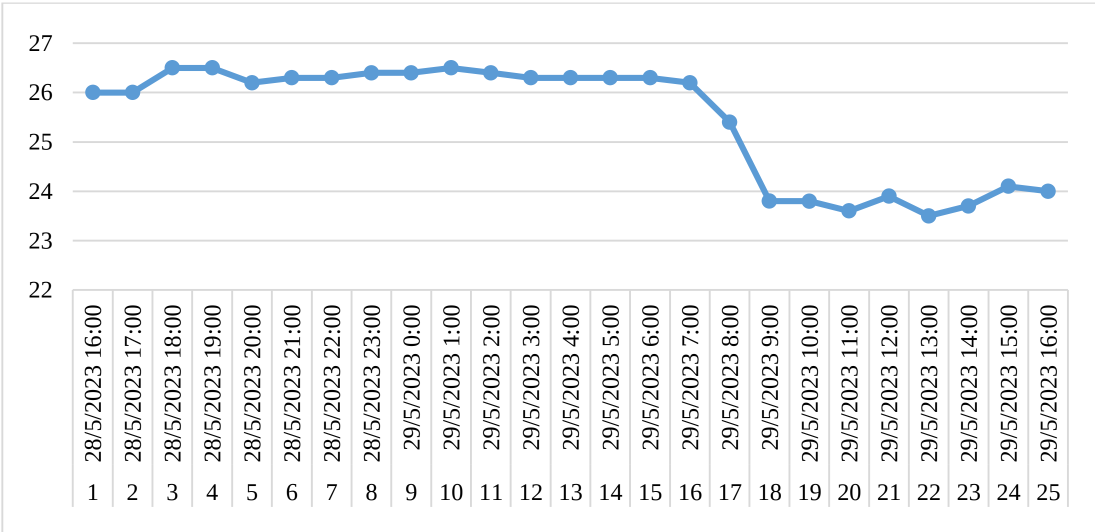

Figure 3: Graph for temperature in Electrical Technology Laboratory in 24 hours

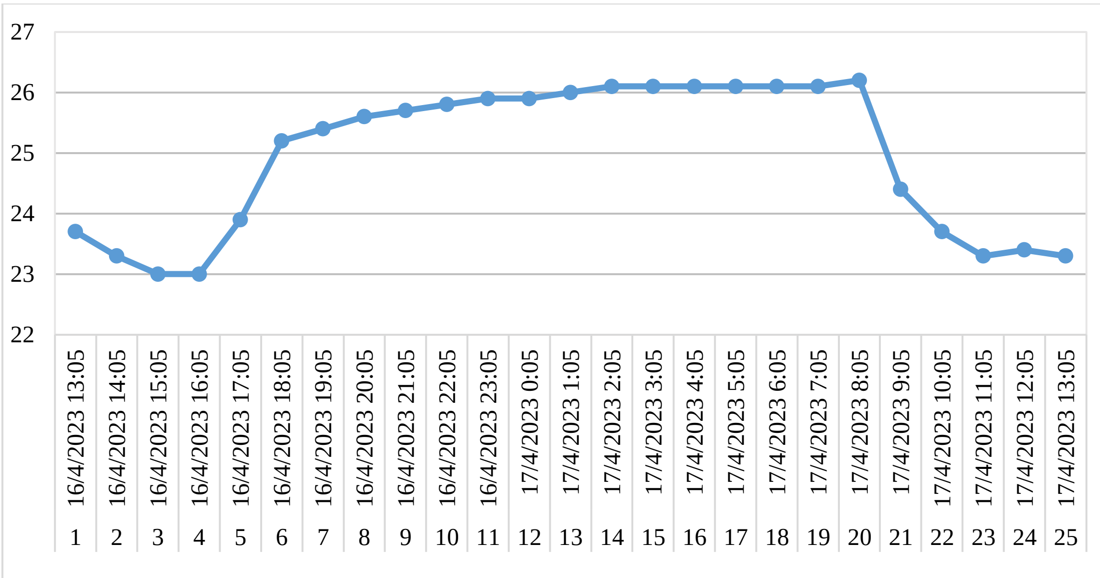

Figure 4: Graph for temperature in Building and Surveying Services Laboratory in 24 hours

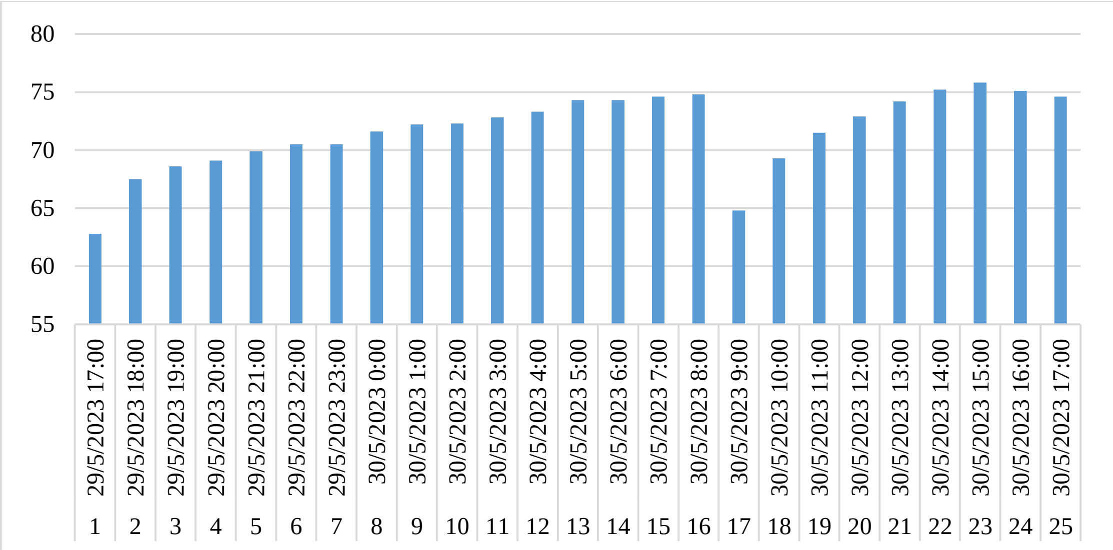

Figure 5: Graph for humidity in Electronic Laboratory in 24 hours

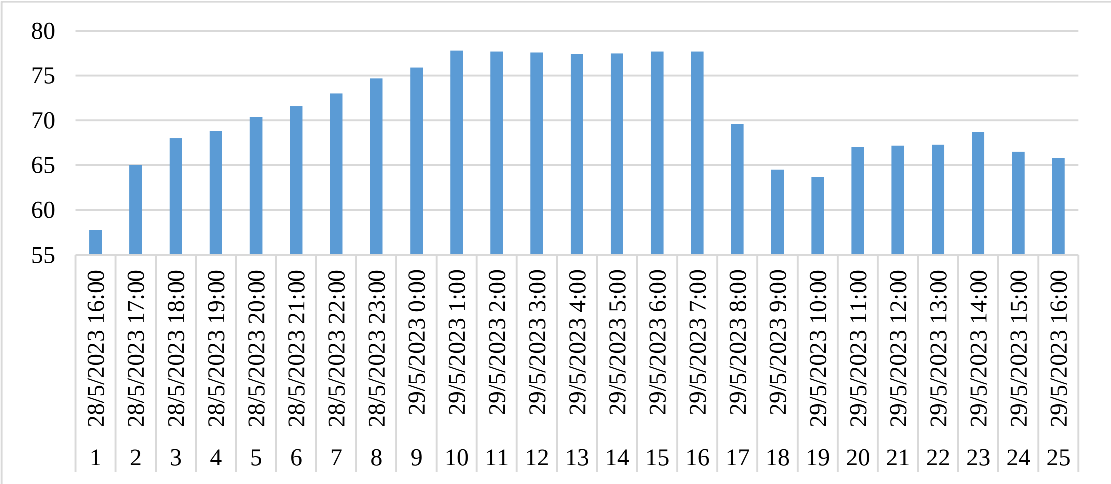

Figure 6: Graph for humidity in Electrical Technology Laboratory in 24 hours

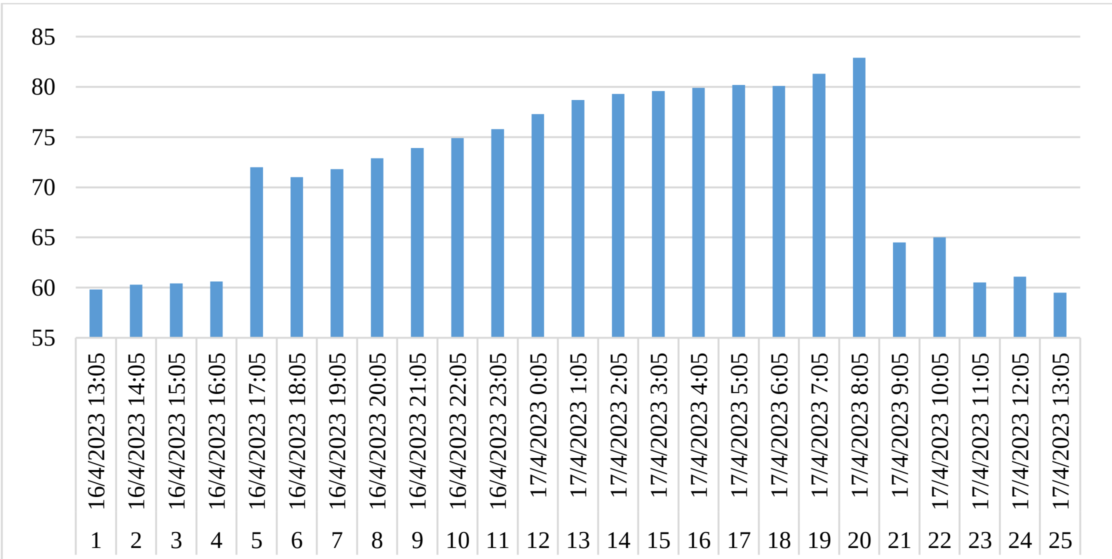

Figure 7: Graph for humidity in Building and Surveying Services Laboratory in 24 hours

3.3 Results and Discussion for Building Load Profile

Figure 8 shows the iSCADA Report data logging output was performed for 17 days from 01 Apr 2023 00:00:00 until 17 Apr 2023 23:59:59. The power load profile observations shows that the average data of power of peak time energy use in weekdays is 32949.54kWh and the average data of power of off-peak time energy use in weekdays is 7006.55kWh.

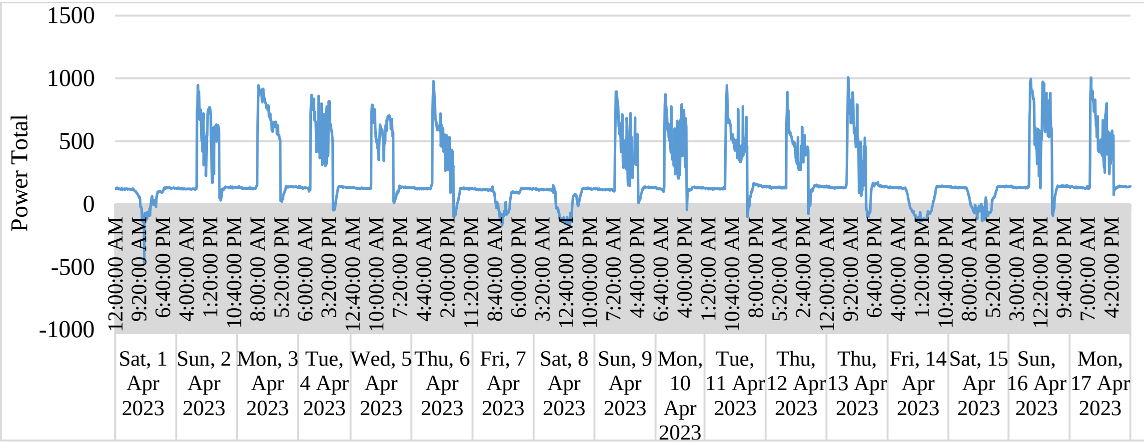

Figure 8: Load profile for 17 days during online class session

Figure 9 shows the iSCADA Report data logging output was performed for 18 14 May 2023 00:00:00 until 31 May 2023 23:59:59. The power load profile observations shows that the average data of power of peak time energy use in weekdays is 60493.16kWh and the average data of power of off-peak time energy use in weekdays is 8825.82kWh.

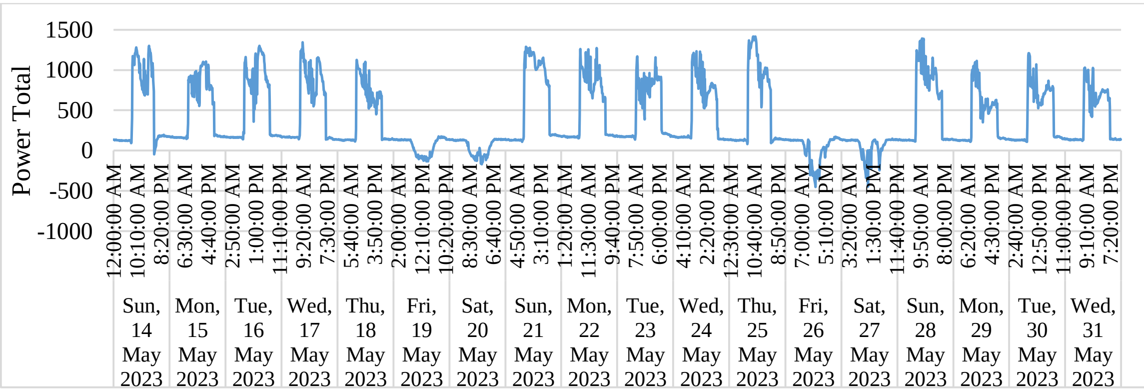

Figure 9: Load profile for 18 days during physical class session

The data on the graphs indicate that the total electricity usage differs between physical classes and online classes. The average peak time energy use in a physical class session is 45.53% higher compared to an online session, while the average off-peak time energy use is 20.61% higher. Online classes consume less energy due to various reasons. Physical classes require energy-intensive components such as lighting, HVAC systems, projectors, and audio-visual technology. Other energy-intensive buildings on campus also contribute to overall energy usage. In contrast, online classes focus more on individual device usage and include additional energy usage for typical domestic tasks. Physical classes have a broader range of energy-consuming components spread throughout the campus, whereas online classes are less reliant on specific gadgets.

4. Conclusion

In conclusion, the study presented comprehensive results and discussions regarding illuminance levels, temperature, humidity, and energy usage in various laboratory settings. The illuminance measurements highlighted that most areas in the Electrical Technology Laboratory, Electrical Power Supply Laboratory, and Building and Surveying Services Laboratory were within or near the recommended standards, with variations attributed to natural lighting and room layout. In contrast, the Micro Teaching Lab exhibited consistently higher illuminance levels due to both artificial and natural light sources.

The analysis of temperature and humidity revealed that, overall, the laboratories maintained suitable conditions, except for the Electronic Laboratory, where humidity levels slightly exceeded acceptable limits. Managing humidity is crucial to prevent detrimental effects on equipment and overall indoor environment quality.

The investigation into building load profiles during physical and online class sessions indicated substantial differences in energy consumption. Online classes exhibited lower energy usage due to their focus on individual devices, while physical classes demanded more energy-intensive components, contributing to the overall energy load on campus.

To address energy efficiency, the energy audit project proposed a range of measures. This included routine maintenance to improve equipment efficiency, optimizing cooling system temperatures, reducing equipment and lighting usage hours, and implementing energy-efficient lighting solutions such as LED lamps. The analysis demonstrated that implementing LED lamps in the Micro Teaching Lab could lead to significant energy savings and financial benefits over time. The financial analysis outlined the investment cost, payback periods, and return on investment associated with this LED implementation, illustrating its feasibility and potential for long-term sustainability.

In summary, the study's findings underscore the importance of monitoring and optimizing lighting, temperature, humidity, and energy usage in laboratory environments. By implementing energy-saving measures and leveraging technologies like LED lighting, institutions can not only enhance energy efficiency but also contribute to cost savings, environmental sustainability, and improved indoor conditions for occupants.

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