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Electrical Energy Audit at Faculty of Technology Management and Business, Universiti Tun Hussein Onn Malaysia

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Abstract: Energy consumption may increase due to some factors such as surrounding temperature and humidity. The inefficient system operated will demand more energy to provide a comfortable and healthy environment. Besides, it is very important to have an energy audit because to Efficient Management of Electrical Energy Regulations 2018 (EMEER) is the regulation that was enacted to improve energy management practices among large energy consumers. This paper presents the energy audit at the Faculty of Technology Management and Business (FPTP), UTHM. The audit process includes the findings of the building (illuminance, temperature, humidity, and thermal energy) through a walkthrough and detailed measurements. Excessive usage of electricity may be caused by the low energy management in the building. Inefficient systems may lead to energy waste and other issues. The specification of the system, such as lighting, and chillers, must follow the standardization (MS1525:2014) to provide a good visual environment and comfortable air. All data and information had been analyzed that showed some inefficient system operation. Energy Saving Measure (ESM) obtained and proposed to reduce energy consumption and cost. The implementation of Energy saving in a building will make the building's system more efficient which reduces energy consumption, and cost-saving.

Keywords: Electrical Energy Audit, Energy Saving Measure, Illuminance Level, Thermal, Temperature and Humidity.

1. Introduction

The greatest invention in our life ever made by science is electricity. This invention is excellent and useful because, without electricity, we have difficulties in our daily lives. The invention is essential because it has made our lives easier, such as removing the darkness, fighting heat during the summer

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by using the fan or air conditioning, operating the appliances in our home, etc. Electricity can change our life into the illumination of the heavens.

In addition to the previous view, electricity is also used to run factories, schools, public transportation and all the technologies in this world. In Malaysia, the statistics for energy consumption are increasing every year. According to the Tenaga Nasional Berhad Handbook, in 2017, the energy consumption in Malaysia was 146,524 GWh [1]. In 2018, energy consumption increased two times, which is 152,866 GWh [2] due to high demand from people and aligned with the technologies nowadays.

UTHM was anticipated to grow by a factor of six very soon. All of this occurs due to the high usage of electricity in UTHM. For instance, the use of air conditioning in all the buildings in UTHM besides computers and machines in the laboratory. It is impossible to run the building without any energy consumption. On the other hand, the energy consumption of the building sector consumes the biggest energy, where the energy consumed is 48% of the total electrical energy [3]. This also occurs with UTHM, when the latter's quick development causes a rise in the amount of electricity used.

The excessive use of electricity at University Tun Hussein Onn Malaysia (UTHM) causes the monthly bill to reach approximately RM 700,000 is the main purpose of carrying out this task. This issue led to higher budget requirements and became wasted expenses. In addition, this method of auditing electrical consumption can also be used to identify the pattern of electricity consumption in each building in the UTHM area. Therefore, the specification in the buildings is expected to follow the regulation (MS1525:2014) [5] which is Malaysian standard. Other than that, referring to the EMEER, after the ending of the six-month period consecutively from the date the installation begins generating electricity, a private installation licensee pursuant to paragraph 3(2)(d) shall submit to the Commission information or documents on the net amount of electricity generation for any period not exceeding six consecutive months equal to or exceeding 3,000,000 kWh [6]. The energy consumption of a building can be improved by increasing energy management efficiency. Based on the energy demand by the facility, energy-saving measures can be proposed to avoid extra energy consumption.

This project is about auditing the electrical energy consumption at a selected building in UTHM, Faculty of Technology Management and Business. The audit consists of the data of illuminance level, the humidity of the environment, and the thermal imaginary of the faculty to ensure that all the energy indexes as follow the regulation Malaysia standard for Building Energy Index (BEI), which is (MS1525:2007) where the standard Building Energy Index is 135kWh/m2/year [4]. Therefore, this audit can also determine the energy-wasting in building areas, saving energy consumption in the FPTP building.

2. Methodology

This section will discuss the process of energy audits being conducted from the beginning until the end. There are two flowcharts for the project's flowchart and the energy audit's flowchart. Those will clearly show the steps and flow of work. There is also an equipment list and building floor plan attached that have been used in this project.

A. List of Equipment

1) Lux meter (UT381/382)
2) Humidity/Temperature Datalogger (UT330A/B/C)
3) Thermal Imager

B. Method of using equipment

1) Lux meter

Illuminance level will be measured by dividing an area into small areas. The width and length of an area will determine the points of the measurement. In other words, it can be related to the room index that contains factors of width, length of spaces, and useful height[7]. Different areas may have different purposes which also may have different useful heights. As a result, the result measured will show the points that may have issues including the excessive illuminance level as shown in Figure 1.

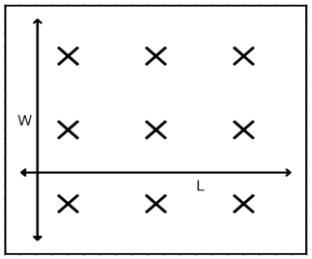

Figure 1: Example of lux measurement points

2) Temperature/Humidity Datalogger

The datalogger meter will be used to record the temperature and humidity of the building. Some areas will be chosen to do the measurement. The measurement only took 24 hours to obtain a more accurate result. The graph of temperature and humidity during office hours and at night. The datalogger needs to be placed in a safe place and detect the surrounding temperature and humidity.

3) Thermal Imager

A thermal imager is used by pointing to the target area which will detect the temperature of the object. In this project, a thermal imager was used to capture and record the temperature of the object that influences the room temperature. Object or anything that prevents the room from cooling.

C. Flowchart of energy audit

The process flowchart of energy audit is shown in Figure 2.

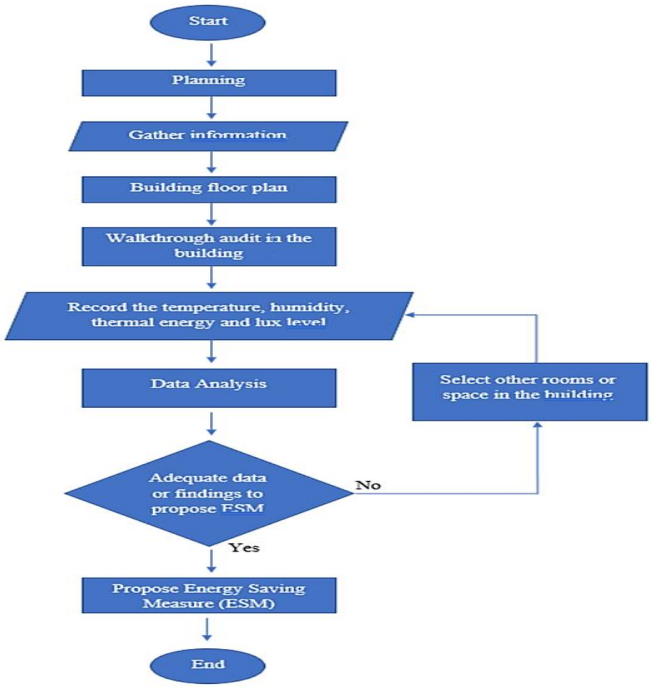

Figure 2: Flowchart of energy audit

D. Planning/Location selection

The initial step is to prepare a plan and think about the processes that will be required throughout the implementation of this project. The selection of the building is based on the list of buildings available at UTHM. After observing the list of available structures, the Faculty of Technology Management and Business (FPTP) building will serve as the site for this project's implementation.

E. Data collection

The walk-through in the FPTP building area is one of the processes of data collection. The walk-through process will give some observation roughly on the site condition. The data obtained will be useful in the detailed energy audit. The detailed energy audit may include measurements and other information. The data that is collected by walkthrough is important for analyzing the process. Thus, the following things will be focused when collecting the data:

i. Measured the illuminance level of the lighting system in the specific area.
ii. Recorded the data for temperature (˚C) and humidity (%) of the surrounding area.
iii. Measured the thermal energy of the material/component in the building.

The process of data collection was conducted only during office hours. The building is supposedly not consuming much electricity after office hours except for the lighting in common areas like the corridor, lobby, foyer, etc.

F. Building Floor Plan

Based on the floor plan obtained from Pejabat Pembangunan dan Penyenggaraan UTHM, here is the list of areas in the FPTP building from the Ground floor to 2nd floor as shown in Table 1.

Table 1: List of areas in level G,1,2

No.	Floor	Room Name
1	Ground	Bilik Kuliah 1
2		Bilik Kuliah 2
3		Makmal Bahan Binaan
4		Makmal Geomatik
5		Makmal Mekanik Tanah
6		Makmal Pengeluaran dan Operasi
7		Makmal Teknologi Pembuatan
8		Makmal Automasi Industri
9		Bilik Komputer
10		Ruang Menunggu
11		Bilik Bincang 1
12	1	Dewan Kuliah
13		Bilik Operasi
14		Makmal Pengurusan Alam Sekitar
15		Makmal Pengurusan Harta Tanah
16		Makmal Struktur Binaan
17		Makmal Kualiti dan Pengukuran
18		Makmal Komputer Pengurusan Projek dan Inovasi
19		Bilik Bincang
20		Bilik Mesyuarat

21		Ruang Menunggu
22	2	Makmal Komputer dan Multimedia 1
23		Makmal Komputer dan Multimmedia 2,3,4
24		Bilik Kuliah 4
25		Bilik Sumber Pelajar
26		Laluan Bilik Penyelidik
27		Makmal Komputer Pengurusan Fasiliti
28		Bilik Kuliah 3
29		Makmal Pasca Siswazah 1
30		Makmal Kualiti dan Pengukuran
31		Makmal Komputer Pengurusan Projek dan Inovasi

Table 1 is the list of spaces on every floor. Other areas that are rarely used, like the lecturer's and staff's room, and strictly not allowed will be except for the measurement. Those areas, rooms, or spaces are considered the personal responsibility of their owner. FPTP building is having renovation at level 3 and above that cannot be accessed.

3. Results and Discussion

This section explains the findings that were obtained by implementing the methodologies mentioned in the previous chapter. Then, the results obtained by the energy audit process at the FPTP building have been done in several rooms but only Bilik Sumber Pelajar will be explained in this paper. For temperature and humidity, the data were collected in the areas that are commonly used in the building, especially the office, lobby, and classroom.

A. Lux test

The illuminance level of areas in the building will be measured. The measurement for illuminance is the so-called Lux test. Areas that were measured were divided into grids based on the space width as tabulated in Figure 3. This is because every spot in the area may have a different illuminance value. By doing this, the measurement accuracy may be increased compared to measuring only at one spot of the area as shown in Table 2.

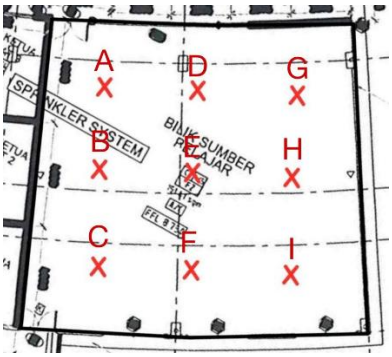

Figure 3: Bilik Sumber Pelajar

Table 2: Illuminance level in Bilik Sumber Pelajar

Point	Lux measured	Lux recommended by MS1525	Point	Lux measured	Lux recommended by MS1525
A	2400	300-500	F	2400	300-500
B	2120	300-500	G	2120	300-500
C	1748	300-500	H	1748	300-500
D	1100	300-500	I	1100	300-500
E	2580	300-500			

By observing the data measured in areas in Table 2, some differences are affected by the arrangement of light, the structure, the lighting point, and the lamp's number. The most influencing factor to the lux value is the sunlight from external. Besides being installed with many lights, their surrounding windows are not covered with a curtain, which naturally lightens up the area. The original design for each room could possibly be used for other purposes like the laboratory and library. The room usage has been changed to the classroom, so there will not be that high illuminance level.

B. Temperature and humidity

A few Rooms and areas were chosen based on the areas that are frequently used and measured the temperature for 24 24-hour periods. The selected areas are mostly used in the building such as the classroom, office, and lecturer room lobby. This is because these areas use using air-con system every working day during working hours. By using the data logger to record the data of the temperature, the obtained results are attached below.

Based on the observations of temperature measurement in the building, the temperature was recommended within 24-25℃. Pejabat Pentadbiran the only room/area that has an average temperature of 24.5 ℃, while other 26.0℃ and 30.1℃ for Makmal Bahan Binaan and Bilik Ketua Jabatan Lobby respectively as shown in Figure 4. When the temperature is low or higher than 24-25℃, the Energy Saving Measure can be proposed. There are some possibilities that influenced the room's temperature to become low such as thermostat issues, bad insulation of the areas, etc.

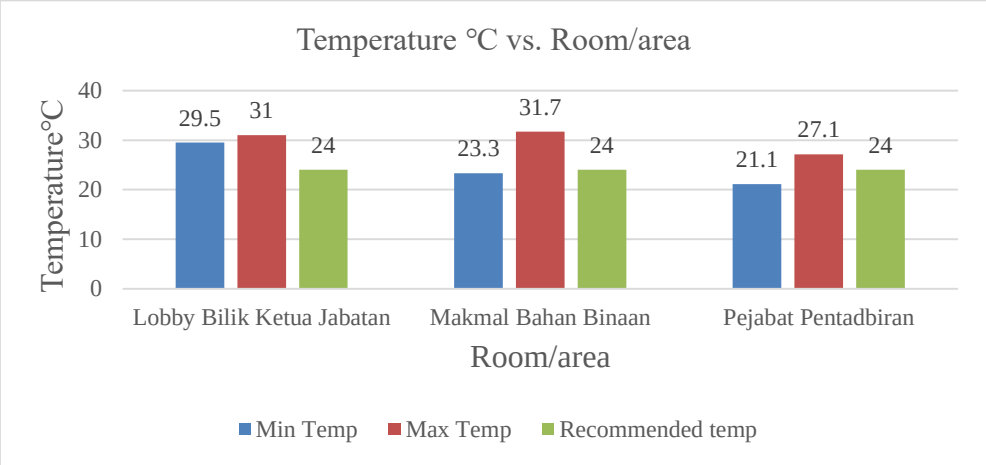

Figure 4: Temperature of three different rooms and the recommended temperature.

Humidity refers to the amount of moisture or water vapor present in the air. It is a crucial factor in understanding and maintaining indoor comfort, as it affects our perception of temperature and overall well-being. The humidity level or relative humidity of three different rooms was plotted as above. As recommended by the MS1525, the humidity level recommended is 70%. Figure 5 shows the Bilik Ketua Jabatan Lobby for minimum and maximum percentage is around 70% which scores average humidity of 67.9%. Then, for the Makmal Bahan Binaan the minimum and maximum humidity level is a bit different from recommended value. The average humidity percentage was 67.3%. Lastly, the average humidity percentage in Pejabat Pentadbiran was 74.9% which is a bit higher than the recommended level. Thus, maintaining optimal humidity levels is essential to provide comfort in an indoor environment.

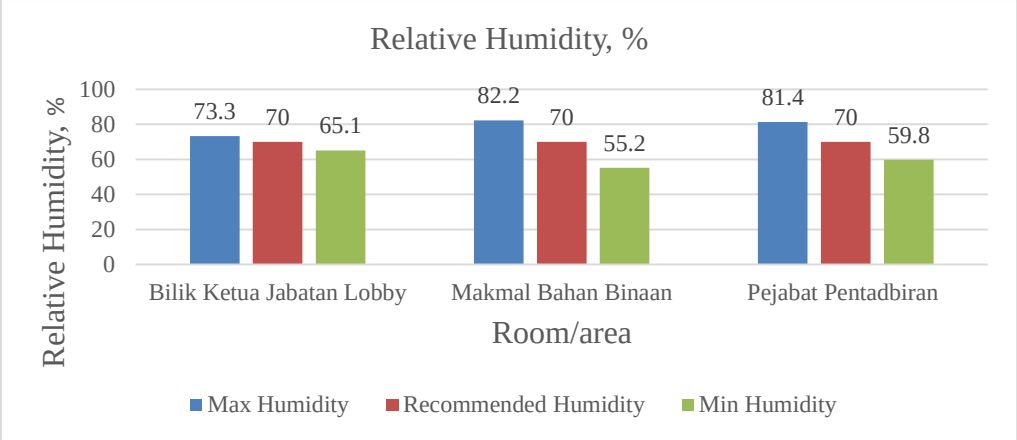

Figure 5: A humidity level of 3 different rooms.

C. Thermal energy

The term "thermal energy" refers to the energy that already exists in a system because of the movement and vibration of the particles that make up that system. At the microscopic level, it is a kind of kinetic energy that relates to the temperature of an item or substance. Thermal energy is proportional to the temperature and increases as it rises. Conduction, convection, and radiation are the three primary means by which thermal energy is transferred from one location to another. It is essential to keep in mind that while thermal energy is the primary component in determining the temperature of a space, other aspects, such as ventilation and air circulation, can also influence how the temperature is distributed across the area.

Thermal energy appearance is shown in Figure 6 (a) where at Lobby Bilik Ketua Jabatan. The heat was detected at the glass of the door where sunlight was allowed to enter through it. Thermal energy is primarily determined by the sources of heat present, such as heating systems, sunlight, appliances, or even human bodies. When these heat sources release energy into the room, the thermal energy increases. As a result, the temperature of the room tends to rise. The external heat gets transferred into the room by a window in Makmal Pengurusan Harta Tanah. The thermal image of the window is in Figure 6 (b). The difference between room temperature and outside temperature can be observed clearly with the cooler and the warmer. The process of heat transfer from one source to another will occur and balance the temperature. As a result, room temperature is difficult to reach low cooling temperatures unless they outsource heat. These findings were also found in other rooms since most of the rooms in this building were equipped with this type of door and window.

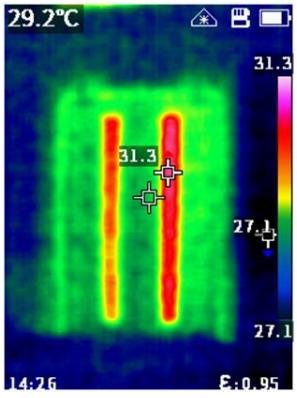

Figure 6 (a): Thermal image of door

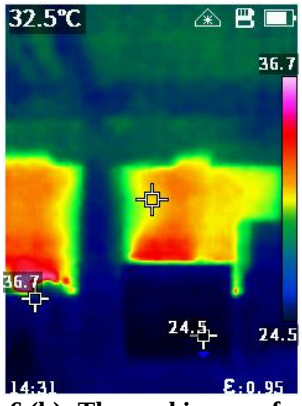

Figure 6 (b): Thermal image of window

Most of the rooms in this building were installed with this type of door and window. The shades and curtain design are also equipped with similar types.

D. Building Load Profile

The load profile of FPTP building was recorded in two different sessions which were during online classes session and physical classes session. The first period was from 1st April 2023 until 17th April 2023(17 days) where the learning sessions were conducted virtually. The load profile attached below shows in detail the load profile of the building. Based on Figure 7, it clearly shows the total power for both periods and the difference. Next, average power consumed a day for 12 and 14 working days during 1st April-17th April, and 14th May-31st May respectively.

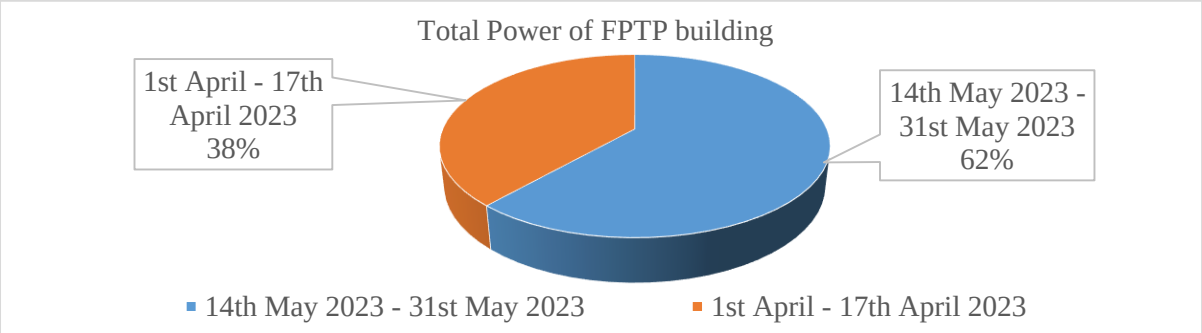

Figure 7: Pie chart of total power difference between two sessions

Based on Table 3, the average power consumed per day of FPTP building during two different sessions was calculated. The average power a day during the online class session was 7656.42kWh and 11266.30kWh for the physical session. Thus, the total payment was paid for a day in 2 different sessions:

Table 3: Average power per day for two different sessions

Session	Total Power on Working Days	Time (Working days)	Average Power/day
1st -17th April Online	91877.03kWh	12	7656.42kWh
14th – 31st May Physical	157728.23kWh	14	11266.30kWh

Table 4 shows the estimated bill of electricity for a day. During the online class session, the bill for electricity is RM 2794.59 for a working day. However, the bill for electricity from 14th to 31st March 2023 is RM4112.20 and students attend the faculty's building for the lecture sessions. There is a huge difference between these two sessions on electricity bills because the consumption of energy by the load is low during online classes compared to physical class sessions.

Table 4: Estimation bill per day

Session	Average Power/day	Tariff	Bill (RM)/day
1st -17th April (Online)	7656.42kWh	0.365	RM 2794.59
14th – 31st May (Physical)	11266.30kWh	0.365	RM4112.20

E. Energy Saving Measures

Data collected during the energy audit might be at different places for lighting, temperature and humidity and thermal energy. An Energy Saving Measure (ESM) is proposed for the entire building to reduce energy usage and improve the efficiency of the whole building's systems.

F. ESM for Lighting System

The lighting system installed in this building uses fluorescent tubes (T8, 36W), incandescent, and CFL. These types are less efficient and consume more power to produce enough lumen. Thus, to

improve the efficiency of this system, the ESMs proposed some solutions with multiple options with different costs. The ESMs for lighting systems are tabulated in Table 5.

Table 5: Energy Saving Measure Recommendation

No.	Saving Measure Recommendation	Cost
1	Delamping	No Cost
2	Replace Fluorescent Lamps with LED Lamps	Medium Cost

4. Conclusion

In summary, the objective of this energy audit study was to measure the illuminance, temperature, humidity, and thermal in FPTP building's areas. The building's current patterns of energy usage and data collected have been analyzed. An exhaustive review of the data and energy systems of the building has led to several major hypotheses and findings. It was found that a significant amount of energy was being wasted due to inefficient usage of the lighting system and cooling system. This energy audit study shows some wastage energy due to some low-efficient equipment which consumes extra energy. Energy can be saved while providing a comfortable environment with the recommended standard illuminance, temperature, and humidity. Then, energy-saving measures were obtained and proposed for each system including lighting and air-conditioning system. By implementing the proposed saving measures, the building may be able to dramatically cut its consumption of energy and will have a positive impact on long-term operation costs.

Acknowledgement

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