IMPLEMENTATION OF SUSTAINABLE ENERGY MANAGEMENT SYSTEM (SEMS) AT ADMIN BLOCK OF FKE

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A report submitted
in partial fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled "IMPLEMENTATION OF SUSTAINABLE ENERGY MANAGEMENT SYSTEM (SEMS) AT ADMIN BLOCK OF FKE is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this report entitled "IMPLEMENTATION OF SUSTAINABLE ENERGY MANAGEMENT SYSTEM (SEMS) AT ADMIN BLOCK OF FKE" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : ....

Supervisor Name : ....

Date : ....

DEDICATIONS

Dedicated to my beloved parents, siblings and friends for the support, encouragement and understanding

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ABSTRACT

This reports present the implementation of sustainable energy management system to achieve 3 star energy management gold standard rating for Faculty of Electrical Engineering by 2019. Faculty of Electrical Engineering, Universiti Teknikal Malaysia Melaka (UTeM) has developed an energy saving plan using Sustainable Energy Management System (SEMS). It has been introduced by the Asean Energy Management Scheme (AEMAS) and Green Tech Malaysia since 2010 which contributes to reduce the energy consumption as well as offers excellence sustainable development, low carbon economy and good corporate responsibility respectively. From this report, we can see reduction of energy as well as produce significant impact to the Energy Efficiency Index and Cost Saving. The admin building of Electrical Engineering Faculty that consist of three blocks (Block A, B and C) is selected to study and determinate its overall lighting, air conditioning system and electrical appliances structure. The major problem are how to improve and monitor the performance of energy consumption and also how to reduce the energy that have been wasted in this building. This an energy lighting, air conditioning and electrical equipment audit classified into two section which preliminary and detailed audit which review and tracking on electrical appliances installed used and its performance of energy consumption. This paper consider energy efficiency index (EEI) as indicator of energy consumption performance. Hence, energy saving can be made by applying SEMS and the main problem of admin block are solved.

ABSTRAK

Projek ini membentangkan pelaksanaan sistem pengurusan tenaga lestari untuk mencapai penarafan standard emas pengurusan tenaga tiga bintang untuk Fakulti Kejuruteraan Elektrik menjelang 2019. Fakulti Kejuruteraan Elektrik, Universiti Teknikal Malaysia Melaka (UTeM) telah membangunkan pelan penjimatan tenaga menggunakan Sistem Pengurusan Tenaga Lestari (SEMS). Ia telah diperkenalkan oleh Skim Pengurusan Tenaga Asean (AEMAS) dan Green Tech Malaysia sejak 2010 yang menyumbang untuk mengurangkan penggunaan tenaga serta menawarkan pembangunan lestari yang mampan, ekonomi karbon rendah dan tanggungjawab bersama yang baik. Dari laporan ini, kita dapat melihat pengurangan tenaga serta menghasilkan kesan yang ketara kepada Indeks Kecekapan Tenaga dan Penjimatan Kos. Bangunan Pentadbiran Fakulti Kejuruteraan Elektrik yang terdiri daripada tiga blok (Blok A, B dan C) dipilih untuk mengkaji dan menentukan struktur sistem pencahayaan dan penyaman udara keseluruhannya. Masalah utama ialah bagaimana untuk memperbaiki dan memantau prestasi penggunaan tenaga dan juga bagaimana mengurangkan tenaga yang telah digunakan secara berlebihan di bangunan ini. Bagi audit pengawalan pencahayaan tenaga dan penghawa dingin diklasifikasikan kepada dua bahagian untuk audit permulaan dan terperinci yang meninjau dan mengesan jenis peralatan elektrik yang dipasang dan penggunaan tenaga. Maka, projek ini mengganggap penggunaan indeks kecekapan tenaga (EEI) sebagai penunjuk prestasi penggunaan tenaga. Oleh itu, penjimatan tenaga boleh dibuat dengan menggunakan SEMS dan masalah utama Blok Pentadbiran dapat diselesaikan.

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EEI	-	Energy Efficiency Index
SEMS	-	Sustainable Energy Management System
G	-	Ground
LED	-	Light Emitting Diode
JKR	-	Jabatan Kerja Raya
HVAC	-	Heating, Ventilation, and Air Conditioning
FKE	-	Faculty Electrical Engineering
PSM	-	Projek Sarjana Muda
UTeM		Universiti Teknikal Malaysia Melaka

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Electricity consumption in commercial buildings have consistent attention as electricity is large energy source that have been used in building [1]. The cost of fossil fuel has steadily increased year by year. Malaysia's electricity tariff will increase as the result of fossil fuel price rise.

In Malaysia, the strong demand from domestic and commercial sector make the demand for electricity is going rise. It is grow in tandem with its Gross Domestic Product (GDP). The demand of electricity will increase if GDP rising continuously, but in different path. Around 1.5 of Malaysia electricity GDP, meaning that for every 1% rise, electric consumption rise by 1.5% [2]. Therefore, the country is going to need more electrical energy to achieve high income status.

The use of electrical appliances is often linked to building energy utilization especially air-conditioning and lighting [3], which each have a very large parts of energy consumption. Most of the rate of energy consumption given by surrounding, management, environmental, building construction and design, mechanical and electrical equipment. [4].

Table 1-1: Energy use in building that effect parameters. [4]

End-Use	Factors
1. Air Conditioning	Occupancy and Building Design and Construction
2. Lighting	Environmental Standard
3. Power and Process	Climate Building design and construction

	Mechanical and Electrical Equipment.

The annual consumption most of typical Malaysian office buildings in Figure 1.1 .Its show that total building energy consumption are 58% from air conditioning, followed by lighting (20%), office equipment such as printer, projector and other (19%) and (3%)[2]. By year 2020, 32 million people to be expected population in Malaysia. This 75% expectation of population will live in modern areas. This shows that the rate of energy consumption will rising due to modern home appliances such as air conditions [5]. In addition, lighting becomes the second electric consumption [6].

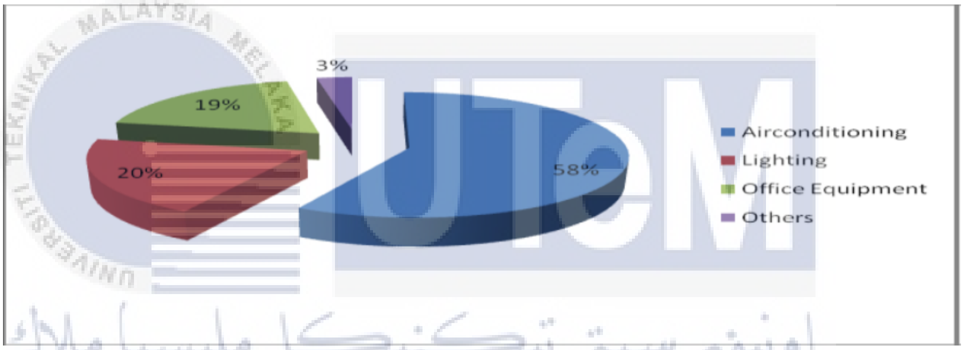

Figure 1-1 Annual Consumption [2]

Based on this matter, gross floor area cannot be ignored in power consumption, since energy consumption based on per unit floor area [4]. On theoretical, the bigger gross floor area of the building, more energy will be consumed. For a building, the meaning of Electric Efficiency Index (EEI) is attach to the size of building and mostly considered as energy used per unit building area. EEI is expressed in kWh/m^2, the saving energy consumption are the lowest EEI

1.2 Motivation

Admin building of Faculty Electrical Engineering is one of the commercial buildings that consume high energy since the building area size is large. Now, Univerisiti Teknikal Malaysia Melaka (UTeM) has achieved 1 star energy management gold standard rating on 2017.For this year, by end of November, the audit will be made to certified that UTeM will be awarded the 2 star rating under ASEAN Energy Management Scheme (AEMAS).Most of the energy used are flowing to lecture hall, admin building and lecturer room since all of the student and lecturer main activities spend in this building. As the main electricity usage are lighting and air conditioning, energy waste that occur should be identified and at the same time it must using less energy to provide the same energy to encourage sustainable energy management system. To reduce power consumption, performance of energy consumption can be monitor by applying energy efficiency index which it is provides the energy performance comparison. So that it can raise awareness of the building efficiency and start to plan the target for the improvement of energy consumption.

From this report, the power consumption can be analyzed by collecting data of air conditioning, lighting and electrical equipment in order applying the building sustainable energy management system (SEMS) at Admin Block of FKE.

1.3 Problem Statement

The commercial building need a serious awareness since the electricity is the main energy source used. With the increasing of fuel price, its effect consumer to use the electricity continuous and wisely. An energy audit is the one of step undertaken to determine what, when and how energy is used in a building. In order, it is to know the basic problem of the wasting of energy consumption. Most of the electrical load that act as major consumer of electricity in the building are air-conditioner , lighting and office equipment. At that point, FKE's staff and student has slightest energy mindfulness which most of them always take granted by leaving the lecture room with light switch on and running waste of energy and increment utility usage.

Besides, the temperature inside the admin building are higher. There are most of the glasses window are not tinted yet leads to heat move from outside of building into inside of the building. Air Handling Unit (AHU) or Fan Coil Unit (FCU) sometimes failed to cool the area of building because of the power needed to cooling the building are not enough for the space so that the compressor and fan control need to work out more than usual. This will lead to increasing of power consumption.

In addition, Admin Block of FKE has been conduct savings program that related to energy efficiency and energy saving. Therefore, the energy saving should be maintain with any suggestion of SEMS. It is one of the important things to uniform the electrical appliances performances and at the same time decreasing the energy consumption, fulfill consumer demand and reduce the electrical bills.

Energy management system is one of the method to prevent UTeM paying uncontrolled electrical bill. Energy consumption and maximum demand effect the electrical bill. Type of electrical loads, working hours, consumer demands, the temperature surrounding, the quality material of building and people behaviors.

1.4 Objective

There are three objectives to be achieve at the end of this project:

i) To collect and analyze data energy consumption at Admin Block.

ii) To calculate and determine the Energy Efficiency Index (EEI) on the admin building of FKE.

iii) To suggest the sustainable energy management system (SEMS) at Admin Block of FKE

1.5 Project Scope

As admin block is one of the block classification that require to identify power consumption, strategic planning should be formed to achieve energy efficiency. Data collection including lighting, air conditioning and electrical equipment at admin block of FKE. Perform the preliminary and detailed energy audit for lighting, air conditioning and electrical equipment at admin block which consist of Block A, B and C .EEI are determine to track the performance of energy consumption in admin building. By applying sustainable energy management system, to assure that energy of lighting, air conditioning and electrical equipment has been efficiently used, the process of managing the energy consumption should be done. So that, it will verified that SEMS are successful increase the energy performance at Admin Block of FKE

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

By developing energy efficiency, the energy consumptions and greenhouse gas emissions can be lowered indirectly. In order to reduce global warming, sustainable energy management system (SEMS) is the most successive path to guarantee a protected and feasible energy supply. To attain the energy efficiency, the power consumption of Admin Block must be analyzed first by performing preliminary audit, detailed audit and next recommendation plan for improving power consumption can be proposed.

2.2 Introduction of Sustainable Energy Management System (SEMS)

SEMS is the process of managing the energy consumption in the organization to assure that energy has been efficiently consumed. It cover all aspect of energy consumption in the organization and involves not only machines or equipment that consume energy but also looks for the best operations from operators. In order, Nigim and Reiser [7] the efficient use including various of renewable and non-renewable energy resources while limiting the natural resources in the definition of sustainable energy. According to Bossel [8], to sustain the power consumption, it need to fulfil two condition. First, the renewable sources sustainably managed to all energy and secondly high efficiency of energy must use and distributed.

For the sustainable energy management system, Choong [9] suggested how to implement energy management in a university, All of these suggestion were grouped in three major part which is planning, implementing and also monitoring and evaluation. While John and Gorp [10] research that by consistently applying energy management, energy saving will be able to be maintained over time. By ensuring that each building in university will be able to improves power consumption and eco-environmental building

Government initiative are to reduce energy usage in Malaysia, UTM [4] has launched several energy saving campaign in 2010 such as 'Sustainable Campus Campaign' and 'Go Green Campaign' within campus to reduce energy and billing. The sustainable energy management system recommended by Mohammed [11] involving the replacement of fluorescent lamp with LED, increasing temperature air condition of building and implement of renewable energy such as solar.

2.3 Energy Consumption

Energy consumption for commercial building present significantly towards maximum energy demand, mostly in developed countries. Most of number electrical energy being contribute over time to run an electrical appliance. Energy consumption can calculate an electrical system or total electrical appliance. Many method have been present to measure energy consumption precisely [12].

$$\text{Energy Consumption (kWh)} = \text{Power Consumption x operating hours} \qquad (2.1)$$

2.4 Electricity Tariff

Electricity tariff are the amount of money frame by the supplier to supply the electrical energy to various type of consumers. The higher prices for the fuel, the higher cost to generate electricity to consumer because fuel cost can vary during times of high demand. The electricity rates are different for domestic, commercial and industrial consumer. TNB tariff rates are different for tariff A, B, C1, C2, D, E1, E1s, E2, E2s, E3, E3s, F, F1, F2, G, G1, H, H1 and H2. From Table 2-1, shows the electricity tariff for medium voltage general commercial tariff. The price for each kilowatt of maximum demand per month are RM30.30 /kW and for all kWh 36.50 cent /kWh. So that the minimum monthly charge is around RM600.00 [13].

Table 2-1 Electricity tariff for medium voltage general commercial tariff

Category of tariff	Unit	Price
Tariff C1- Medium Voltage General Commercial Tariff		
a) For each kilowatt of maximum demand per month during the peak period.	RM/kW	30.30
b) For all kWh	Sen /kWh	36.50
c) The minimum monthly charge	RM	600.00

2.5 Maximum Demand

Maximum demand (MD) is the biggest level of electrical demand that normally carried electrical system. The measured of maximum demand in kilowatt (kW). The power consumed are over a period of time during a 30 minute interval in a month. The electrical bill are consumed based on the MD [14].

The MD that charge by TNB has different rate because on peak time TNB need to generate more electricity. When there is a lot of electrical equipment run on the same time, there will be the highest MD..

2.6 Energy Efficiency

Energy efficiency is by using less energy and at the same time it is provide the same level of energy. For an example, if the whole house has insulated, there have reduction of energy used in cooling to achieve sustainable temperature [15]. Most of high efficiency equipment depends on the electrical system which is lighting, air conditioning system or others.

2.7 Concept of Energy Efficiency Index (EEI)

Energy Efficiency Index (EEI) is one of the indicator that used to track the performance of energy consumption in buildings. This index also as reference which have energy performance comparison. To organize an effective energy saving, EEI offer the best understanding on the building efficiency scheme for the future [16]. Usually, a factor related to the energy using component are as given in equation (2.2) and examples of factor that have relationship to energy use are as below [4]:

- Product that produce weight.
- Number that item produced
- Weight of material used
- Period
- Period of plant have used
- Area of building
- Number of patient bed per night
- Number of occupied people

$$EEI = \frac{Energy\ Input}{Factor\ related\ to\ the\ energy\ using\ component} \tag{2.2}$$

Most of the building, the meaning of EEI is always calculate in the size of the building and usually considered as energy used per unit of area of the building which can be determined using equation (2.3) [4].

$$EEI = \frac{Total\ energy\ used\ (kWh)}{Gross\ Floor\ Area\ (m^2)} \tag{2.3}$$

2.8 Energy Audit

Energy audit process are evaluating the usage energy that have been used within building and it can correctly identify the benefit to reduce the energy consumption. Energy audit that apply energy analysis methods to determine pattern and flow of energy consumption. This is the first step to improve energy efficiency buildings area. Its apply energy inspection methods to assess flow and trend of energy consumption and efficiency option in commercial, industrial, government and household buildings [17].

Preliminary audit also known as walk-through audit. Firstly, site visit to the building facilities to determine where simple and inexpensive solutions. It will provide instant energy-use and cost saving of operation. Besides, to estimate the saving potential without including the accurate measurements are the step preliminary audit [18].

Next, by applying detail audit which is specifically detailed of energy audit includes the use of tools to measure energy use and the energy system such as lighting, building equipment, fans and chiller. The recognition of energy efficient measures can effectively reduce energy consumption, greenhouse gas emissions and the energy bill [17].

2.9 Energy Management Gold Standard

The Energy Management Gold Standard (EMGS) is companies or organizations that categorize as the brand of quality for sustainable energy management system awarded by AEMAS. It has 3 level of certification which is 1-star, 2-star and 3-star. To be certified under AEMAS, companies or organizations will be checked on energy management performance based on the level of fulfilment to the following criteria which are Management, Organization, Process, Information, Financial, Social responsibility and Achievement. The Energy Management Gold Standard can be achieved by an organization that undergoing the AEMAS certification [19].

Table 2-2: Criteria for 1-star, 2-star and 3-star EMGS

1-star	2-star	3-star
• An energy management system based on the ISO 50001 • An AEMAS-certified Energy Manager (CEM) - Certified after 3 day training on managing • The action obtaining policies and internal investment criteria favouring energy efficient technologies	• An energy efficiency management system based on the ISO 50001 • Overall Energy Efficiency Index (EEI) improves by at least 5% (over 2 years) • EEI improves by at least 1% on year-on-year basis over the past 3 years • Energy Efficiency (EE) measures representing at least 50% of the total energy saving potential • Investment in five new energy efficiency technologies	• Professional Energy Manager (PEM) NOT Certified Energy Manager (CEM) • Policies and internal investment criteria “Energy Efficiencies friendly” • Proven Energy Efficiency Index (EEI) improves 5% lower within 2 consecutive years

2.10 Lighting

Around 30% to 40% lighting system consume of the electricity used in commercial buildings. This section amount about one third of a building's electricity bill. Lately, the electricity usage for lighting is generally inefficient. In addition, there is chance to improve the energy efficiency of lighting in every part. Before this, research form other countries have proven that assumption of energy efficient lighting technologies has possibly reduce the amount of energy in buildings. In Australia, a recent survey of companies found that 23% of energy efficiency could be successful by increasing energy saving of lighting system [2].

In Malaysia, the second electric power consumption are lighting after air conditioning. Its show that increasing every year. Reduction in power consumption of lighting will leads to decreasing of cooling load as well as global warming and greenhouse gas emission. According to Rozana Zakaria [6] the total energy consumption of lighting decreasing around 47.7% over a year by replacing the fluorescent T8 with fluorescent T5.Most of the lighting design standard in Malaysia is refer to MS1525, energy efficiency and use of renewable energy for non-residential buildings. It is developed by SIRIM and one of standard in Malaysia for design building, lighting and electrical appliance and system.

2.10.1 Type of Light

Electrical light is one of the electrical system that produces of visible light. It is providing indoor lighting for buildings and exterior lighting for nighttime activities. Regardless of the light sources selected, there are various type of lighting such as incandescent lamp, fluorescent light and LED lighting.

Fluorescent lights exist in a wide variety of shapes and sizes such as T8 lightings and T5 lightings. Both T5 and T8 is becoming the lighting of choice in residential and commercial building. The different of both light bulbs are T5 tend to be shorter length and diameter. T8 lights are offer around 3000 lumens that typically consume 32 watts per bulb. In addition, T8 can stabilized by electromagnetic and electronic ballast to improve efficiency. While T5 offer around 5000 lumens with power consumption per bulb are 14W, 21W, 28W and 35W. T5 operating hour much shorter than T8 operating hour [20].

LED light stand for ‘Light Emitting Diode’, a semiconductor appliance that convert electric current into light. LED one of super energy efficient, the use of electricity around 85% lesser than other type of lighting. Its shows that electrical bill can saving more significant. The lifespan of LED lighting much longer than other of lighting. When switching on, it will give instant illumination and there is no warm up and cool down time.

Figure 2-1 Fluorescent Light [20]

Figure 2-2 LED Lamp

2.10.2 Level of LUX

LUX is a standardized unit measurement of light level intensity which is commonly known as illuminance or illumination which is equivalent to one lumen per square meter (lm/m^2). This is to measure the strength as perceived by the eyes from light that hit the surface. Lumen are measure luminous flux whereas flux are same to illumination (E) times area (A). Basically, LUX function are to determine the amount of acceptable lumens that needed illuminating a building area.

Most of electrical system, referring to Malaysia Standard (MS 1525:2007) and guideline from Jabatan Kerja Raya (JKR). By referring to Malaysia standard, it can standardized the lighting LUX and at the same time its advancing the economy, for sake of health and safety of public, protecting the consumer, furthering international cooperation and facilitating domestic and international trade. **Table** 2-3 are shows guideline LUX level from Malaysia Standard (MS 1525) and JKR.

Table 2-3 Guideline LUX level from Malaysia Standard (MS 1525) and JKR[1]

General Building Area		MS 1525	JKR
CIRCULATION AREA			
Corridor		50	100
Lift		100	100
Stairs		100	100
Escalator		150	100
External Covered Ways		50	30
ENTRACES			
Entrance halls, lobbies, waiting rooms		100	100
Enquiry desk		300	300
Gate Houses		200	200
STAFF ROOM			
Changing locker and cleaner’s room		100	150
Rest rooms		150	150

OFFICE			
General office with mainly clerical task and typing office		300-400	500
Deep plan general offices		300-400	300
Business machine and typing		300-400	300
Filling room		200	300
Conference room		300-400	300
OFFICE AND SHOPS			
Executive office		300-400	300
Computer rooms		300-400	500
Punch Card rooms		300-400	600
Drawing offices and boards		300-400	600
Reference table and general		300-400	300
Print room		300-400	300
FURTHER EDUCATION			
ESTABLISHMENT		300-500	300
Lecture theatres general		300-500	300
Chalkboard		300-500	300
Demonstration benches		300-500	300
Examination halls, seminar rooms, teaching		300-500	300
spaces		N/A	N/A
Laboratories			
Staff rooms, student rooms			

2.11 HVAC System

HVAC are stand for heating, ventilation and air conditioning. Nowadays, all building need air conditioning. For smaller buildings, air condition units provided but once the area of building reach certain size it become effect the cost to use a centralized system air conditioning. The centralized system use “chillers” that knows as the biggest air-conditioning units but working principle of this kind air-conditioning are different because of size [22].

2.11.1 HVAC Water Chiller System

The main system for the central cooling plant are chiller, Air Handling Unit (AHU), cooling tower and pumps. Water cooled chiller usually located to basement .This type of chiller perform the same function which is to generate cooling water for air conditioning by abolish the unwanted heat from the building [23].

Chilled water is generated from the evaporator. The chilled water flow away from the evaporator at around $6^{\circ}C$ and is flowing around the building by the chilled water pump. Risers known as the pipes to each floor for the chilled water flows up to the building. These kind of pipes are known as riser no matter the water flow up or down [23].

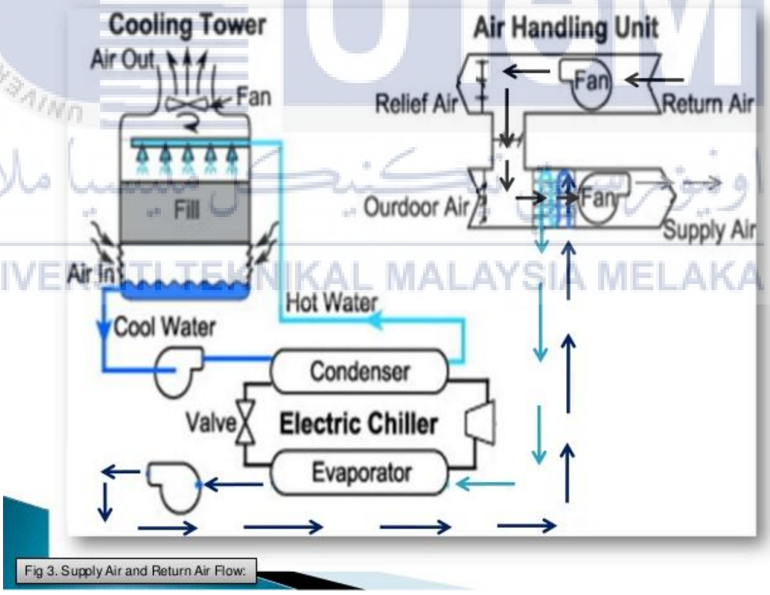

Figure 2-3: Chilled Water System [23]

The branches off the chilled water rises into the smaller diameter pipes which head to fan coil units (FCU) and air handling unit (AHU) to provide air conditioning. Boxes of fans inside the AHU and FCU that absorb air in from the building and flow out across the heating or cooling coils to change the temperature and push back the air out of building. The chilled water heats up and the air blowing across the coil cools down. The water leaves the cooling coil, it will be temperature around 12°C. The water will flow back to the evaporator, refrigerant will absorb the heat and to the condenser. Then it will leave with cool again to circulate around the building [23].

2.11.2 Air Handling Unit (AHU)

The air handling unit (AHU) in an HVAC system performance impact all of the surrounding. This research was reduce the total energy consumption of an AHU system while the temperature in optimum and static pressure of the supply air at an acceptable level [24]. AHU normally have a blower, heating and cooling element besides it is commonly connected to ductwork for the whole building also connected to chiller or condenser unit.

2.11.3 Fan Coil Unit (FCU)

A fan coil unit is a component that have a similar operation to AHU although there are a few difference between it. Basically, it is designed to use chilled water cooling system as a cooling medium to exchange heat in between indoor FCU and outdoor chillers. These type of small AHU have been used in schools, office, restaurants and others building [25].

2.12 Electrical Equipment

Electrical appliances classied as office equipment because it consist of computer, monitor, photostat machine and others. Energy usage of office equipment has risen this recent years because of the growth in technology, density of use and others. Moreover, electrical appliances consume two-thirds of all energy consumed in an average office buildings [39].

Recent effort of manufacturers and government have produce energy rating system to help the consumer find more efficient office equipment in future. By labelling the Energy's Energy Star Logo, indicating that the electrical equipment meets the standard for energy efficiency [40].

2.13 Energy Baseline

An energy baseline are formed by searching what characteristic and variables that affect the building energy use. Besides, it also allow a device to process by comparing energy behavior previously and after an energy management system are applied to the system. For predict energy saving after the implementation of any energy efficiency attempt, there are two things should be consider which are what the energy building uses and what it would have used if there are nothing have been done [26].

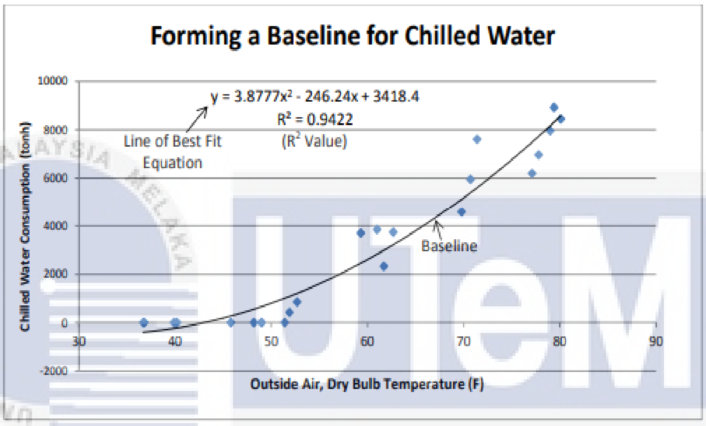

Figure 2-4 Example of Baseline [26]

2.14 Previous Study of Energy Management System

2.14.1 Identification Building Energy Saving Using EEI Approach

Most of the building usually based on per unit floor area, but this existing index still need some improvement in giving accurate analysis in which it cannot measure energy waste by occupants' presence. Building are constructed based on number of people occupant in the certain area to encourage the best energy usage at the same time maintain the energy efficiency of the building [19].

This paper have proposed new energy index logarithm based on the number of occupied room and gross floor area, as shown in equation (2.4) below:

$$EEI = \frac{Total\ energy\ used\ (kWh)}{Gross\ Floor\ Area\ (m^2) \times no of occupant (Person)} \tag{2.4}$$

The unit for this formula is kWh/m^2/person. The relationship between number of occupant and power consumption can be analyze using this energy index formula [19].

The energy management system that have been used to solve the problem are by substitution class. The replacement class has considered this two condition which is the class that still available on the same time can be relocated without having a clash on timetable. Next, the class capacity must fit and achieve the number of students without any increasing and decreasing number of people to achieve a better energy saving. By rearranging the lecture locations and moving the students, the optimum use of energy can be successful [19].

2.14.2 Energy Saving Strategy

From Ahmad Sukri [4], due to high energy consumption statistic, Faculty of Electrical (FKE), UTM has make some strategies to develop an energy management system program which include:

a) Faculty Energy Management Committee established

b) Energy Saving and awareness campaign through talk and online committee survey.

c) Energy audit and study the behaviour of electrical appliances

Energy audit were conducted in FKE to determine where and how savings can be achieved in electrical usage within the organization. Performance of lighting, energy usage of computer and air-conditioning in the laboratory and offices were determined. To encourage the participation of the whole FKE are one of the objective for this paper. So the energy audit results can be used to develop an action plan thus increase energy efficiency. To analyze the impact of strategies, the energy consumption was recorded using the Electrical Billing Management System (EBMS). By this system, energy consumption and cost of energy can be monitored and analyze [4].

In order, this paper has presented Energy Efficiency Index (EEI) baseline for the faculty buildings would enhance energy efficiency practice with Malaysian public university since this kind of strategies has a great impact to the amount energy saved in 2011 compared to 2010 which is 14% of total energy that UTM saved while a reduction of EEI among the building between 5% to 14% [4].

2.14.3 Energy Efficiency Measures

According to J.Gomes [17], a number of opportunity for power consumption to rational were determined, using the information that collected from the energy audit. The implementation of energy efficiency measures can accurately reduce energy consumption, the energy bill and greenhouse gas emission without disturbing comfort of staff and student in the building. The list of measures recommended for applying the energy efficiency measures are:

- By optimizing the contract of the electricity supplier
- Replacement of electromagnetic ballast of lighting with electronic ballast.
- Switching the existing indoor fluorescent lighting with LED lighting technology.
- Replacement of existing high pressure sodium lamps with more efficient lighting.
- Installation of motion sensor in corridors and other internal door area.

This assessment of measure's impact took to reduction of electrical cost and energy consumption [17].

2.14.4 An Integrated Approach To Achieving Campus Sustainability

An integrated approach such as Green Campus for achieving campus sustainability by Habib M. Alshuwaikhat [27]. Green campus one of the way to reduce energy consumption and improve well-being of university community. The aim of the green campus are to have efficient lighting, temperature control, improved the provision of the fresh air to room and indoor air quality which give to healthy environments. So that energy efficiency are improves as building are used efficiently with smart control system.

The Austrian and Japanese study that by adjusting the cooling and lighting system so that the purpose of the building to achieve energy saving increase to 30-70% can be successfully. This study covered all of air-conditioning technology thus energy efficiency could be achieved through the way [27]:

- Use more efficient air- conditioning systems with using wide range of workable passive technologies into overall design for maximum effect.
- Use of renewable energy for day lighting to have large reduction of energy consumption in buildings
- To control off-on heating, cooling and lighting, installing centralized control system.
- Reduce lighting load by improve energy efficiency such as T-8, compact fluorescent and metal halide

CHAPTER 3

METHODOLOGY

3.1 Introduction

This section explains about the procedure taken for this project. Methodology are one of the most important thing in research writing. It is the only section that guide to get the data in order to have an appropriate ways of evaluating the result of research. This project related with the energy audit data of lighting, air-conditioning and electrical equipment at Admin Block of FKE. In order to achieve the objectives of this project, each of the data have a different method to get the result. Furthermore, the Gantt chart will prove timeline for the PSM 1 and PSM 2. The flow of this research will illustrate by flowchart and briefly explain about this research.

3.2 Gantt chart

Table 3.1 shows the overview of the Gantt chart for the whole two semester, Projek Sarjana Muda (PSM1) and Projek Sarjana Muda (PSM 2) . The procedure to complete the literature review research and data analysis are completed in PSM 1 and PSM 2. Refer to appendix A.

3.3 Flow Chart Process

The main work progress of this research are show in this flowchart. It is started at literature review whereas the scope of research was studied first to get any idea based on the research backward. Next, the preliminary audit was conducted to study the building load, structure, schematic drawing and also the system that use for the building. Based on the study, the detailed audit are conducted by collecting the energy usage data, lux and temperature test to meet the Malaysia Standard (MS 1525) and also energy performance of air conditioning by logger. When all of the data are complete, the energy saving measure are proposed to reduce the Energy Efficiency Index (EEI) and energy consumption. Finally, writing report after work progress are complete.

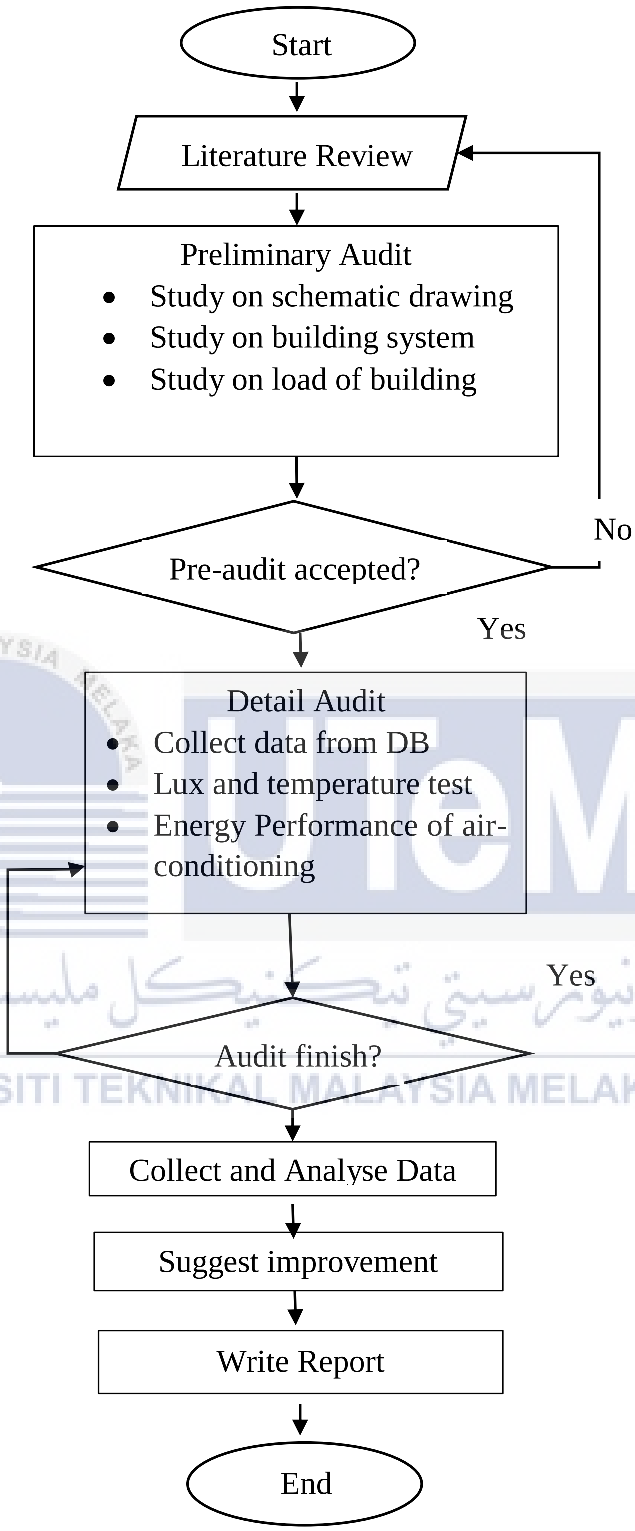

Figure 3-1: Flowchart of Project

3.4 Selecting of Zone in Admin Building

The project conducted at Electrical Engineering Faculty (FKE) which located at Main Campus UTeM Durian Tunggal, Melaka. In 2017, an energy audit overall of the building was conducted due to UTeM is the educational institution that have been register for energy management system. The audit conducted is for overall system of the building including air-conditioner and other loads. For this project, energy audit was conducted specific to lighting, air conditioning and offie equipment.

3.4.1 Zone in Admin Building

The main step to control energy consumption and electrical bill are know when and where the energy are consumed. The facilities audit are within faculty of electrical engineering (FKE), UTeM. Building of FKE consists of six blocks which is blocks A, B, C, D, E and F. This project will focus on admin block which consist of block A, B and C. Admin block occupied by 3 levels of building floor, which are ground floor, first floor, second floor and third floor. Table 3-1 are audited level at admin block of FKE. Then, Figure 3-2 , Figure 3-3, Figure 3-4 and Figure 3-5 show accordingly for schematic diagram Level G, Level 1, Level 2 and Level 3 that mostly locating lecturer rooms, class, admin rooms, meeting rooms and corridor.

Table 3-1 Audited level at Admin Block of FKE

Admin Block	Level
Block A	• Ground Floor • First Floor • Second Floor • Third Floor

Block B	• Ground Floor • First Floor • Second Floor • Third Floor
Block C	• Ground Floor • First Floor • Second Floor • Third Floor

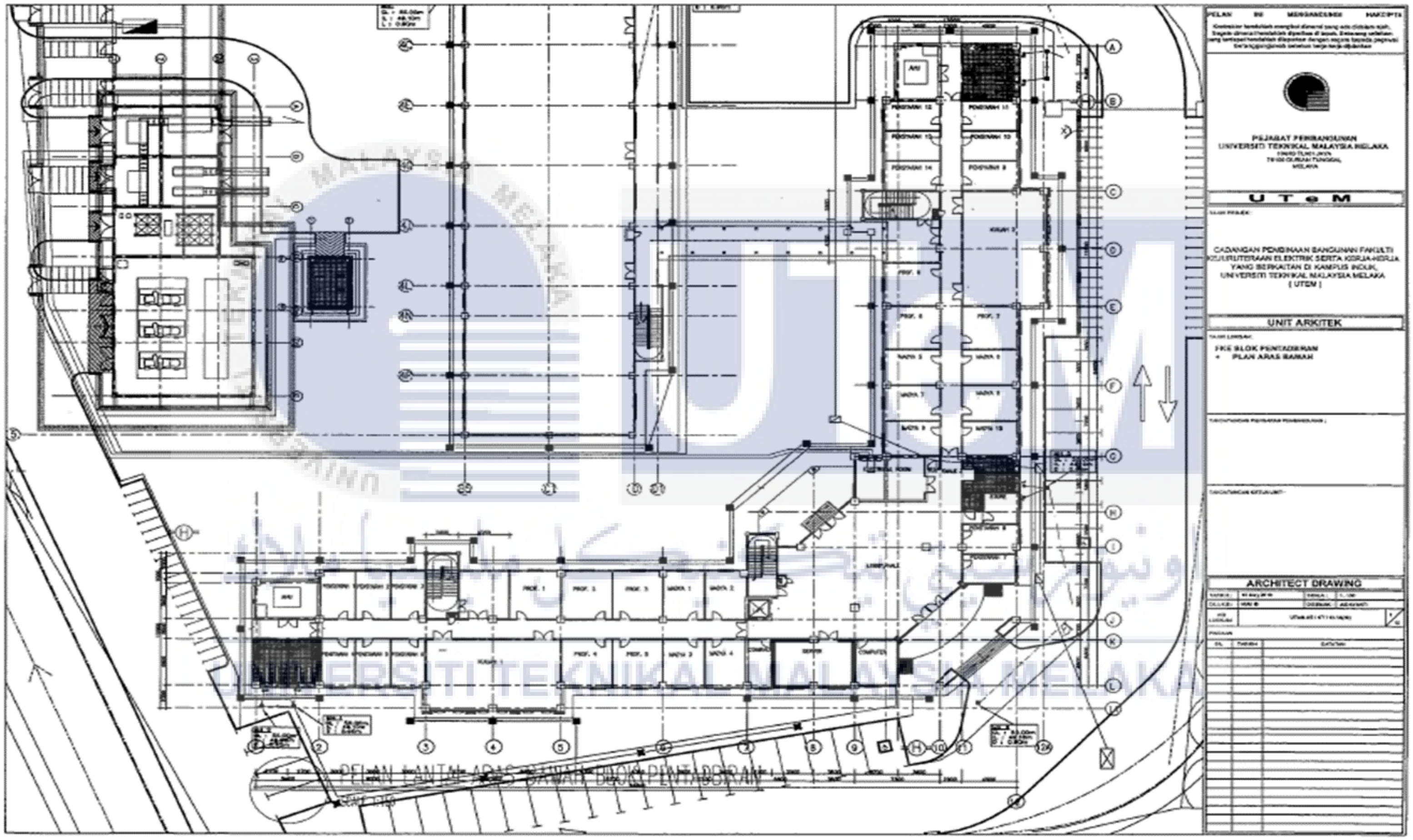

Figure 3-2: Schematic Drawing Ground Floor

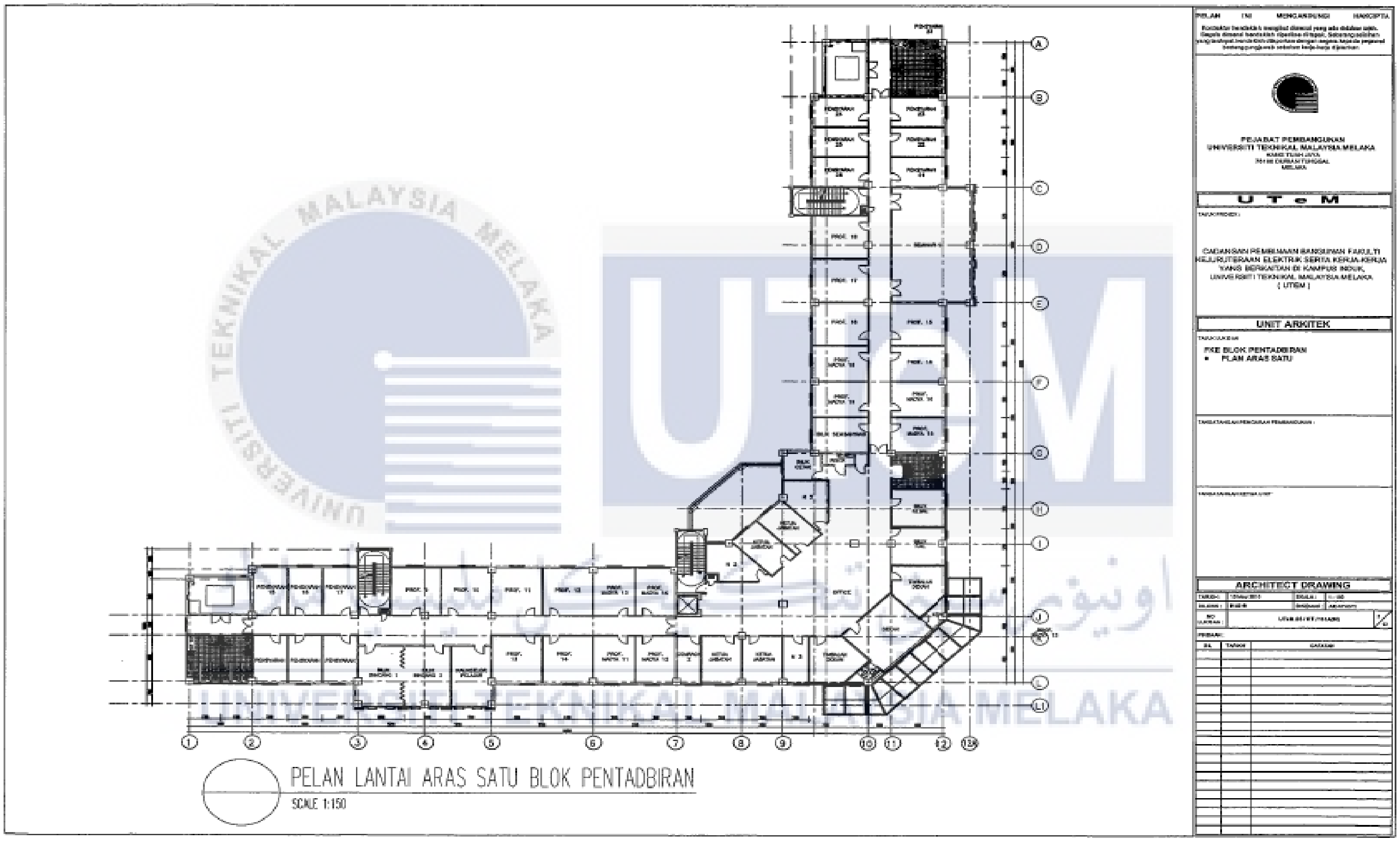

Figure 3-3: Schematic Drawing Level 1

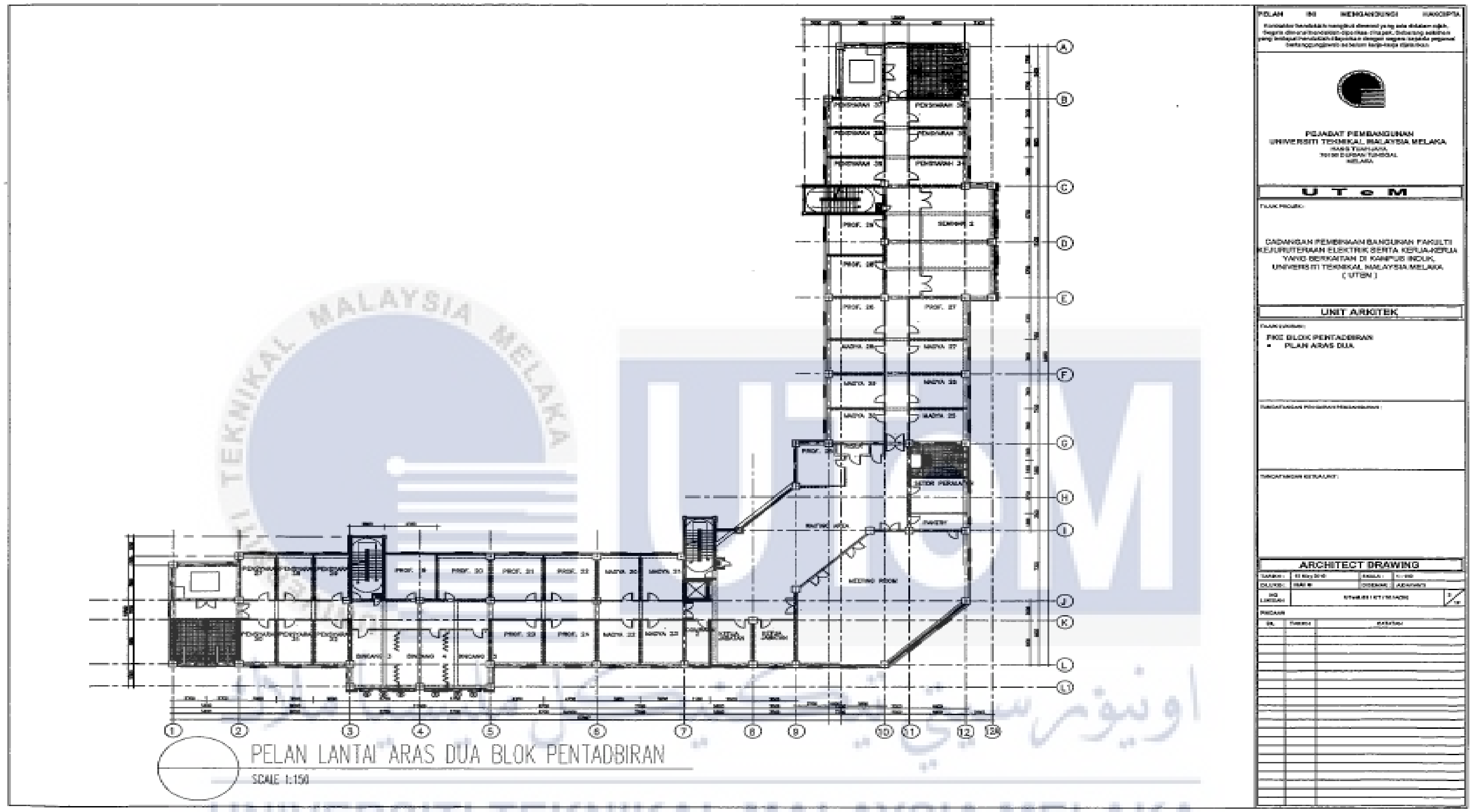

Figure 3-4: Schematic Drawing Level 2

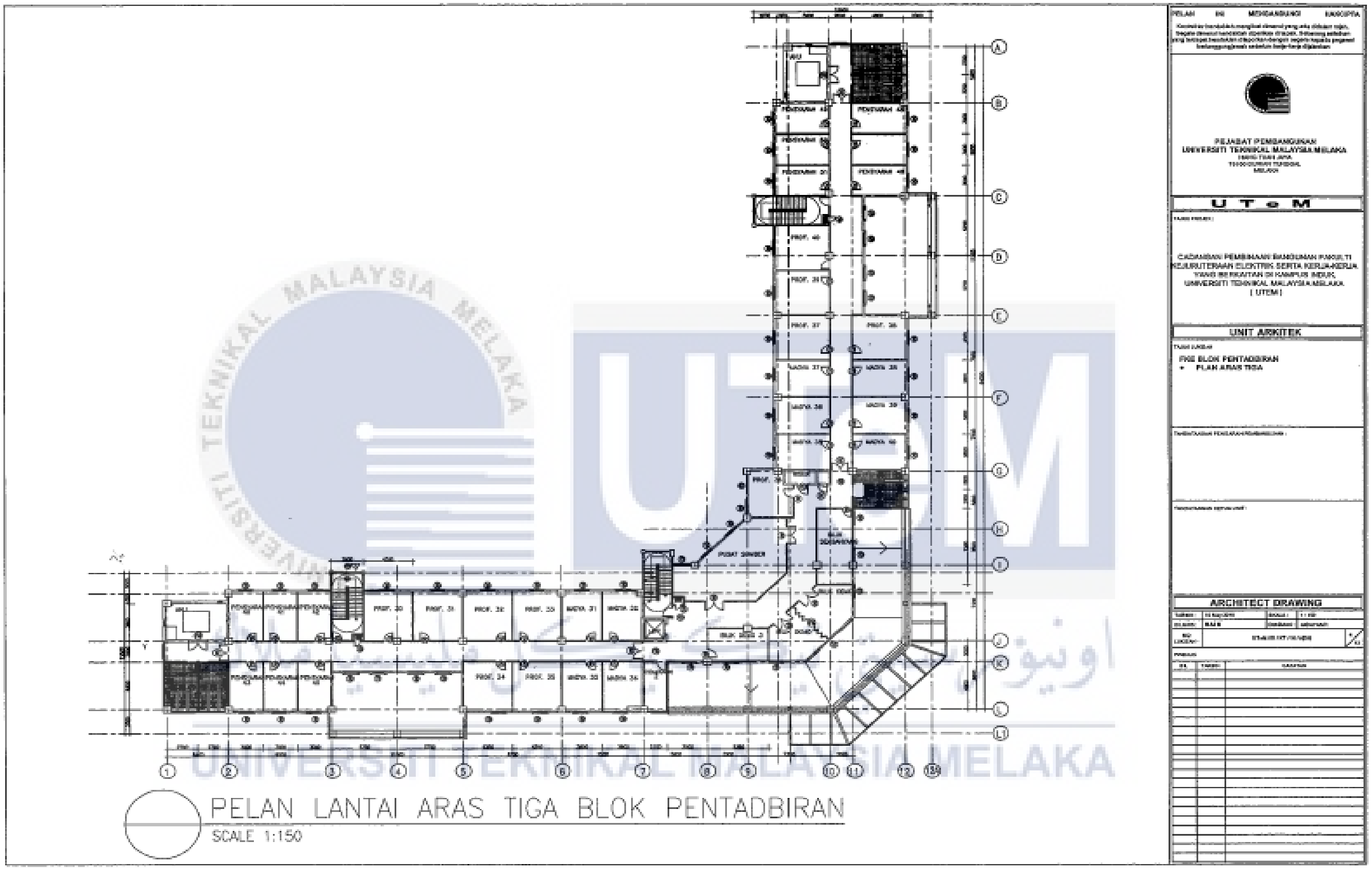

Figure 3-5: Schematic Drawing Level 3

3.5 Literature Review

Literature review needs to be done to gain knowledge in order to improve understanding and give some guideline about this project. This would help the researcher to adapt to new problems and how to solve it. Moreover, the researcher could have a better understanding of this project while increasing the percentage of achieving the objectives.

3.6 Preliminary Audit

The first step of audit are known as preliminary audit. The main objective of the preliminary audit are to understand the building information and to determine the managing plan for potential saving area. The schematic drawing can be obtained from Pejabat Pembangunan UTeM. There have a staff that hold the data for whole UTeM. For study of the building system, it can be done by surveying the building for each level of admin block while the electrical appliances in operating. From the work site survey, it can also studying on the loads by doing inspection of the loads that being used in the building.

The electrical appliances that selected will be compile to calculate the power consumption. For lighting, walk through audit area to collect the data of lighting and type of lighting that have been used. Since FKE used centralized system for air-conditioning, the power consumption have been collect from Encik Luqman which is a person that in charged for air conditioning system for the FKE. Hence the energy baseline will used to show the power consumption of admin block at FKE.

3.7 Detailed Audit

Detailed audit commonly use an analysis from the preliminary audit which are conducted during PSM 1. Basically, the detailed audit are audit and collect the actual measurement and energy consumption for every months in one year. For lighting, the energy consumption of lighting and lux of lighting are the main measurement will be evaluated to identify potential savings. Next, air-conditioning energy measurement are energy consumption of indoor, temperature meter by each block and the energy performance at the busiest floor which is first floor. While for electrical equipment only measure the energy consumption. All of the measurement has its own equipment to collect the measurement. After that the saving measures will be analyzed using technical and economic evaluation. Table 3-2 show the energy measurement will be conducted.

Table 3-2: Energy Measurement

Load	Equipment
Lighting	Lux Meter
Air-Conditioning	Temperature Meter
Distribution Board (MSB1)	Smart Metering (IOT Energy Management System)
Electrical Equipment	-

3.7.1 Process of Flow Chart

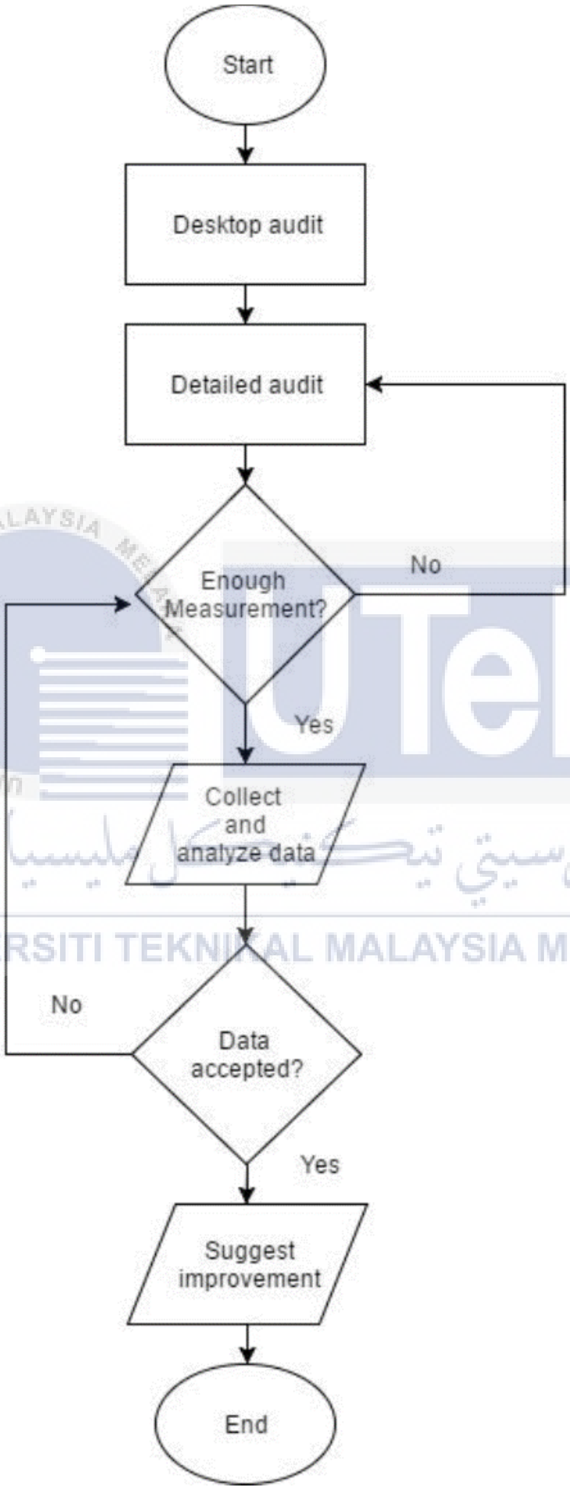

Figure 3-6: Flowchart of Detailed Energy Audit

3.7.2 Equipment Device for Measuring

By collecting the data of energy consumption monthly, the system will be performed load profile to know which load have the highest energy consumption in Admin Block. Then, the highest load of energy consumption goes to air-conditioner. Therefore, the power logger meter are only conducted for air-conditioner indoor unit which is Air Handling Unit (AHU) distribution board. The reading will be taken when equipment are connect to the PEL Logger Software to give an output of the power consumption and energy consumption. Figure 3-7 and Figure 3-8 shows the power logger equipment.

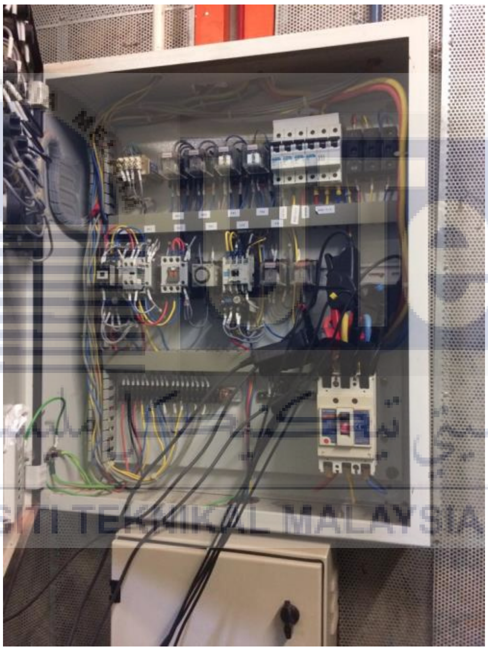

Figure 3-7: Power Logger at First Floor AHU Distribution Board

Figure 3-8: Power Logger Device

The equipment device for air-conditioning are temperature meter. The temperature reading will be tested by using KIMO temperature test of Figure 3-9 that borrowed from Energy Efficiency Laboratory. The reading are show two basic reading which relative humidity on top and temperature reading below. Since the measurement standard are followed TNB temperature measurement which is 24 to 26 degree Celsius at every corner of building. Therefore, only the temperature measurement are taken not relative humidity.

Figure 3-9: KIMO Temperature Meter

Next, the lux reading for lighting are taken from KIMO Lux 100 equipment as shown in Figure 3-10. This equipment also borrowed from Energy Efficiency Laboratory. The lux measurement will be compared with Malaysia Standard (MS1525) which the illuminance contain three level of conditions. There are Under-Lux, Accepted-Lux and Over-Lux. From the measurement, there are a few aspects to be taken as follow:

- Height of the area
- Functions of the area
- Height of Lamp
- Number of people in the room
- Type of lighting and operation hour

Figure 3-10: KIMO Lux 100 Meter

3.8 Energy Consumption and Cost of Electrical

Calculation in this project divided to three part which is calculation for lighting, HVAC system and electrical equipment. For admin block of FKE, there are two types of lighting which is fluorescent light and LED light. While for HVAC system, FKE have been used centralized system of air conditioning. It is chiller water cooling system. All data about the electrical appliance power and working hour will be gathered to calculate energy consumption.

3.8.1 Lighting System

Calculation of lighting system including power consumption, operating hours and rate of tariff.

$$Energy\ consumption\ \left(\frac{kWh}{year}\right) = Power\ (kW) x\ Operating\ Hour\ x\ 365 days \quad (3.1)$$

3.8.2 HVAC System

The basic cooling system consist of two part which is indoor unit and outdoor unit. The indoor unit consist of evaporator, it is air handling unit (AHU) or fan coil unit (FCU). The outdoor unit consist of condenser or cooling tower. The power consumption commonly as below:

$$Power\ Consumption\ (kW) = Power\ \ of\ indoor\ unit\ (kW) + Power\ of\ outdoor\ unit\ (kW) \quad (3.2)$$

The cooling capacity is the most important feature of an air conditioner, this primarily defines the price of the HVAC. Most of air conditioner are rated by tonnage. One ton is equal to 12000 British Thermal Unit (BTU) per hour. One ton of refrigeration (TR) is the amount of heat to be extracted from the atmosphere for melting one metric ton of ice in 24 hours.

$$1\ Ton\ (TR) = 12000\ BTU = 3.517 kW \quad (3.3)$$

In addition, rating of power of an air-conditioning system is the highest power consumption of the load. Hence if power of air conditioning run at maximum potential, the actual power consumption can be calculated by using formula:

$$Power\ consumption = \frac{Required\ cooling\ (\frac{BTU}{hour})}{Cooling\ capacity\ (\frac{BTU}{hour})}\ x\ power\ of\ outdoor\ unit (kW) \quad (3.4)$$

So that energy consumption for the cooling system is obtained and it can be calculated with the formula below:

(3.5)

$$Energy\ consumption\ \left(\frac{kW}{year}\right)$$
$$= actual\ power\ consumption\ (kW) x\ operating\ hour\ x 360 days$$

3.8.3 Total Energy Consumption

Total energy consumption are calculated as formula below:

(3.6)

$$Total\ Energy\ consumption\ \left(\frac{kW}{year}\right)$$
$$= Total\ Energy\ consumption\ \ of\ lighting \left(\frac{kW}{year}\right)$$
$$+ Total\ Energy\ consumption\ of\ HVAC \left(\frac{kW}{year}\right)$$

3.8.4 Electrical Cost

Tariff that have been used in admin block of FKE is Tariff C1 which is medium voltage general commercial tariff. The price for each kilowatt of maximum demand is RM 30.3/kWh and for all energy that have been used are RM0.365/kWh. For the minimum monthly charged is RM 600. Formula for energy consumption price are as below:

(3.7)

$$Price\ of\ energy\ consumption\ (RM) = Tariff\ \left(\frac{RM}{kWh}\right) x\ Energy\ consumption\ (kWh)$$

3.8.5 Payback Period

Payback period is the ratio of total energy consumption for both appliances to the annual power saving and annual energy saving. The calculation as

(3.8)

$$Payback\ Period$$
$$= cost\ of installation\ /(Annual\ power\ saving$$
$$+ annual\ energy\ saving)$$

3.9 Analyze Power and Energy Performance

After power logger at AHU distribution board are complete. The recorded measurement can be obtained from PEL software which is the data are generate to power and energy consumption every one minute for one whole day. Figure 3-11 shows PEL software.

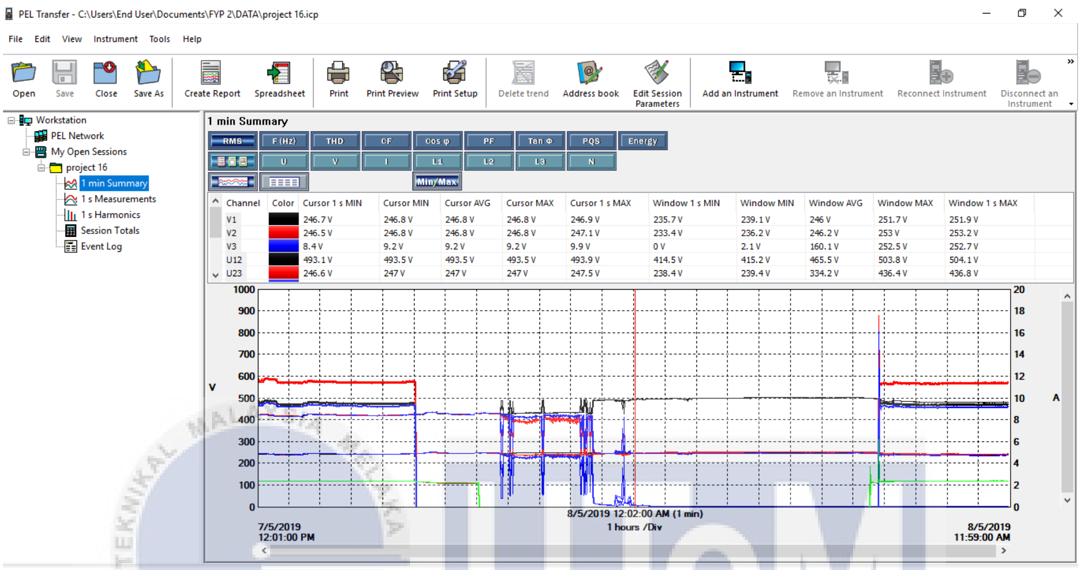

Figure 3-11: PEL Software

All of the data will be transferred to Microsoft Excel to make the detail analysis of the AHU first floor area.

3.10 Electrical Efficiency Index (EEI)

EEI are to determine the performance of energy consumption, it also offer the consumer to understand the building energy utilization. Gross floor area can be calculated by using the drawing of the admin block which is stated in m^2.

$$EEI = \frac{Total\ energy\ used\ (kWh)}{Gross\ Floor\ Area\ (m^2)} \tag{3.9}$$

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Building Analysis

4.1.1 Energy Consumption and Electrical Cost

To obtain the energy usage of Admin Block, the energy area which contain panel of distribution board of FKE have three Main Switch Board (MSB). It is divided to Admin Block, Block D and Block E and also one distribution board for Block F. The energy consumption are taken from the distribution board, one smart meter that automatically transfer the data to computer. Period for the energy consumption are from January to December of 2018 to complete the data for 1 year. The time taken of energy consumption are every 30 minutes, it will show voltage, power factor and current. Table 4-1 below shows monthly energy data and Figure 4-1 shows the energy data in chart.

Table 4-1 Monthly energy data of Admin Block

Month in 2018	**Energy Usage (kWh)**
JANUARY	258,906.26
FEBRUARY	301,381.06
MARCH	252,334.56
APRIL	236,880.96
MAY	160,236.26
JUNE	159,288.76
JULY	209,358.16
AUGUST	199,351.66
SEPTEMBER	175,574.76
OCTOBER	246,753.06
NOVEMBER	240,337.46
DECEMBER	233,007.26
Total	**2,673,410.22**

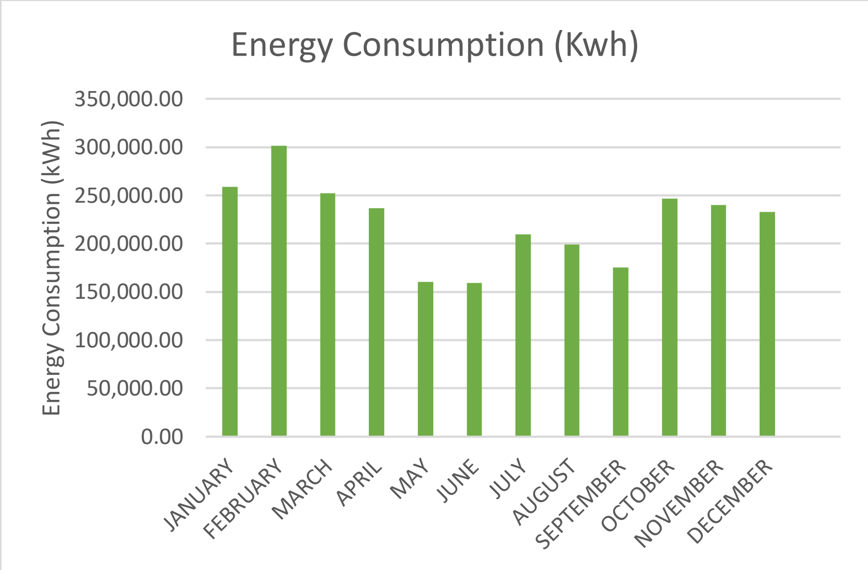

Figure 4-1: Energy Consumption (kWh)

4.2 Load Profile

Figure 4.2 below shows the load profile after the measurement have completely done. Air-conditioning that have been supplied from Air Handling Unit (AHU) and Fan Coil Unit (FCU) has consumed 72% of total load. While lighting only consume 8% since before this FKE have replace fluorescent lamp with LED lamp. Other, the office equipment such as CPU, monitor, fan, Photostat machine and other are consumed 12% from the total load in one year.

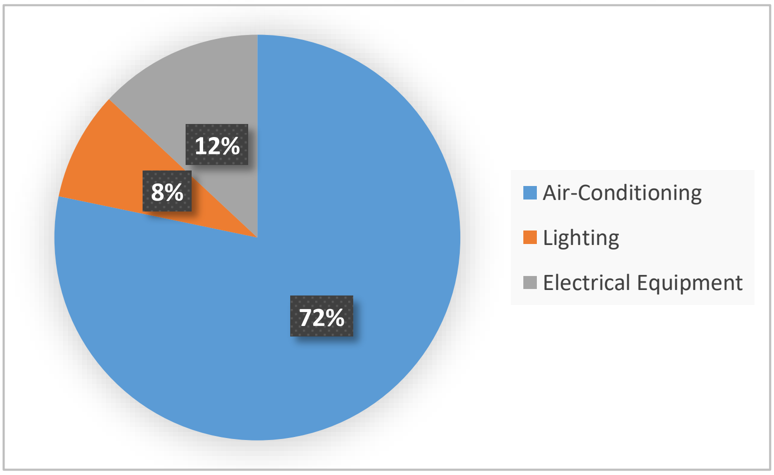

Figure 4-2: Load Profile

4.3 Potential Saving Area

There are three section to focus on for potential energy saving which is air-conditioning (AHU and FCU), lighting system and also office equipment. The inspection and measurement taken are determined only for the selected energy saving measures for each load. Table 4-2 shows the suggestion of energy saving measures that can be proposed for reducing energy usage of Admin Block.

Table 4-2: Proposed energy saving measures

Load	Proposed Energy Saving Measures
Air-Conditioning	Operating Time Scheduling (AHU)
	Reduce Daily Air-Conditioning Temperature
	Install Split Unit Air-Conditioning
	Air-Conditioning Cleaning
Lighting	Install Timer Control
	De-lamping
	Change from Fluorescent Lamp to LED Lamp
	Install Motion Sensor
Electrical equipment	Regular Awareness Program

4.3.1 Energy Efficiency Index (Variable Factor)

An effective method to identify and control energy consumption in specific functional or instrumentation or combination both of it. It is known as energy accounting centre. The regression between variable factor and energy consumption help the organization to target the energy saving method and monitor the efficiency. Table 4-3 shows baseline of the relation between energy consumption and working days every month for 12 months period (January 2018 to December 2018).

Table 4-3 Variable factor and energy consumption

No.	x (Working Days)	y (Energy Consumption)
1	21	258,906.26
2	19	301,381.06
3	22	252,334.56
4	21	236,880.96
5	21	160,236.26
6	12	159,288.76
7	22	209,358.16
8	21	199,351.66
9	17	175,574.76
10	23	246,753.06
11	20	240,337.46
12	20	233,007.26

Figure 4-3 shows the equation developed from the baseline energy and working days. The mathematical equation developed from the baseline energy and working days data is y=6,736.3x +88,619, where y is the energy consumption and x is working days. Coefficient determination R^2 is 0.21 shows the working days does not has good correlation with the energy use. This baseline model will not be used to determine adjusted baseline energy.

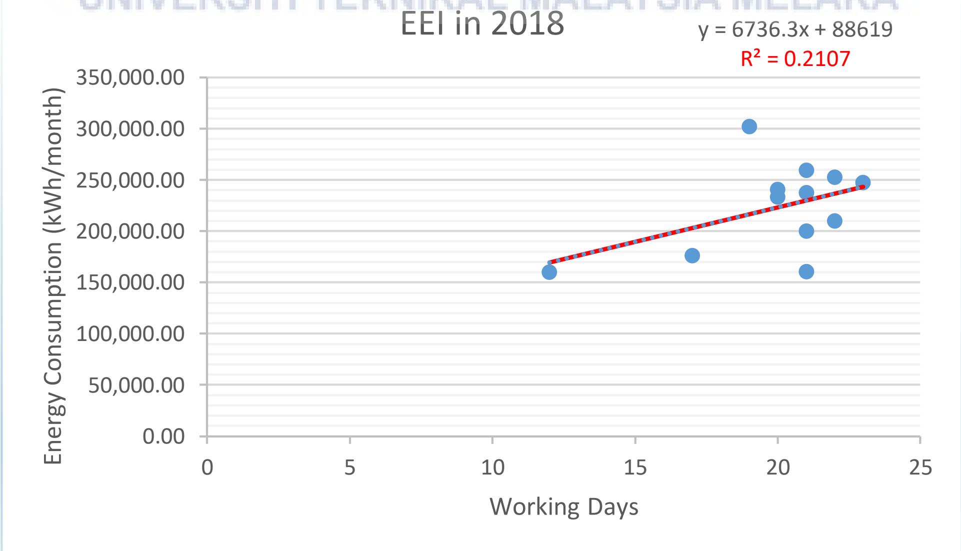

Figure 4-3 EEI in 2018

4.3.2 Energy Efficiency Index (EEI)

Energy Performance Index (EPI) is an international standard is to measure specific energy efficiency of a particular building such as non-residential building. This standard basically measure ratio of energy usage against total area of building to determine the energy performance index. Pusat Tenaga Malaysia (PTM) study that less than 30% of buildings in Malaysia has achieve EEI level which is less than 200/kWh/m^2/year which is consider as energy efficiency building under MS1525:2007. This Malaysia Standard which is MS1525 set a benchmark of 220/kWh/m^2/year maximum EEI bench mark level for a building to consider as energy efficiency building [28].

Admin block consist of three block. It is block A, block B and block C. The EEI are depending on engineering project size. So the total of energy consumption divided to size of area for this project. The EEI analysis shows that when the EEI measurement is increasing, it prove that energy consumption is also increase and indicating that energy waste occurs.

$$EEI = \frac{Total\ energy\ used\ (kWh/year)}{Gross\ Floor\ Area\ (m^2)}$$

$$EEI = \frac{2{,}673{,}410.22}{5{,}387.89}$$

$$= 496.19\ kWh/m^2/year$$

4.4 Air-Conditioning System

The main cooling system in the Admin Block consist of the centralized air cooling system chiller which is the indoor part are Air Handling Unit (AHU), Fan Coil Unit (FCU). There is no air-conditioning split unit system that install in this block. Figure below shows AHU, Chiller System and FCU at Admin Building.

Figure 4-4: AHU rooms

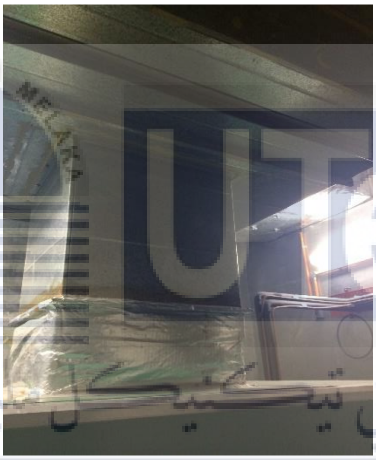

Figure 4-5: AHU Evaporator Coil

Figure 4-6: Chiller of FKE Space

Figure 4-7: Chiller System

Figure 4-8: FCU at Corridor Ground Floor of Block A

4.4.1 Energy Consumption and Cost

The data of air conditioner was taken from Pejabat Pembangunan UTeM. Table 4-4 shows the duty chiller for chiller 1, chiller 2 and chiller 3. For chiller 3, it is act as standby chiller if any trip happened. The capacity for all chiller are same which is 337 RT. While for Table 4-5 shows that the cooling capacity of cooling tower. Heat rejection ton (HRT) are an amount of energy along with the power from the cool side to warm side by the compressor. Table 4-6 shows the schedule of condenser water pump, type of condenser water pump are end suction pump. The required water flow rate are 64 (l/s) and the pump heat for all chiller are around 25m. The motor power pump for condenser are 52.0 kW. Next, Table 4-7 shows total load of AHU and FCU for level ground, level 1, level 2 and level 3. Sensible load are the amount of heat energy that should be removed from a building to maintain the temperature while total load per unit are the actual total load for the whole building.

Table 4-4: Capacity of Water Cooled Chiller

Item	Equipment Unit	Capacity(RT)
1	CHILLER-01	337
2	CHILLER-02	337
3	CHILLER-03	337

Table 4-5 Heat Rejection Tons of Cooling Towers

Item	Equipment Unit	Heat Rejection Tons (HRT)
1	CT-01	845

Table 4-6 Scheduled of Condenser Water Pump

Item	Equipment Unit	Flow rate (l/s)	Pump Head (m)	Motor Power (kW)
1	CWDP-01	64	25	52.0
2	CWDP-02	64	25	52.0
3	CWDP-03	64	25	52.0

Table 4-7 Ton of Refrigeration of Chilled Water AHU and FCU

Reference No.	Location	Quantity	Total Load/ Unit (RT)	Sensible Load (RT)
ARAS BAWAH				
AHU-G/B	Bilik Pensyarah	1	24.00	15.8
FCU-G/B	Kuliah 1	1	5.70	3.1
AHU-G/A	Bilik Pensyarah	1	24.00	15.8
FCU-G/A	Kuliah 2	1	5.70	3.1

ARAS SATU				
AHU-1/B	Bilik Pensyarah	1	29.30	18.5
FCU-1/B	Bincang 1&2	1	3.50	2.1
AHU-1/A	Bilik Pensyarah	1	29.80	19.0
FCU-1/A	Seminar 1	1	5.70	3.1
ARAS DUA				
AHU-2/B	Bilik Pensyarah	1	30.09	20.1
FCU-2/B	Bincang 3,4 &5	1	6.30	3.6
FCU-2/C	Bilik Mesyuarat	1	10.10	4.9
AHU-2/A	Bilik Pensyarah	1	30.09	20.1
FCU-2/A	Seminar 2	1	6.30	3.6
ARAS TIGA				
AHU-3/B	Bilik Pensyarah	1	30.05	22.0
AHU-3/A	Bilik Pensyarah	1	30.05	22.0

4.4.1.1 Calculation of Energy Consumption

i. Power Indoor Unit

a) Level Ground

Total Load/ Unit (RT) = (24.00+5.70+24.00+5.70)
= 59.4RT

1 Ton (TR) = 12000 BTU/h = 3.517kW

59.4RT = 208.91kW

∴ Power Indoor Unit = 208.91kW

b) Level 1

Total Load/ Unit (RT) = (29.30+3.50+29.80+5.70)
= 68.3RT

1 Ton (TR) = 12000 BTU/h = 3.517kW

68.3RT = 240.21kW

∴ Power Indoor Unit = 240.21kW

c) Level 2

Total Load/ Unit (RT) = (30.09+3.6+4.9+20.1+3.6)
= 62.29 RT

1 Ton (TR) = 12000 BTU/h = 3.517kW

62.29RT = 219.07 kW

∴ Power Indoor Unit = 219.07kW

d) Level 3

Total Load/ Unit (RT) = (30.05+30.05)
= 60.10 RT

1 Ton (TR) = 12000 BTU/h = 3.517kW

60.10RT = 211.37 kW

∴ Power Indoor Unit = 211.37kW

Table 4-8: Energy usage and cost for Air Conditioning Central System on Admin Block at FKE

Location	Total Power (kW)	Operating Time (hours)	Energy Consumption (kWh)	Cost (RM)
Ground Floor	208.91	0800-1700	1880.19	RM 686.27
First Floor	240.21	0800-1700	2161.89	RM 789.09
Second Floor	219.07	0800-1700	1971.63	RM 719.64
Third Floor	211.37	0800-1700	1902.33	RM 694.35
		Total	**7916.04**	**2889.35**

4.4.2 Power and Energy Performance Analysis

Air-conditioning has been choosen for power and energy performance analysis measurement with power logger meter. The measurement should be taken at ground floor and first floor but only AHU distribution board first floor are available to conduct power logger. Since power logger should be leave for one day and the AHU rooms must be locked to avoid any missing of power logger equipment because the cost for one equipment are expensive. In addition, FKE only provide one power logger and the limitation of time to collect measurement for other AHU. Since FKE only provide one logger meter, first floor has been choose for power and energy performance analysis. First floor of Admin Block are the busiest floor from other floor with consists of many staff and lecturer at administration area. The analysis including power and energy consumption at peak hour. This floor consist of two AHU which is at Block B and Block A. Admin Block performs repeated schedule every day, which allowed the measurement to be taken only for one day.

4.4.2.1 Analysis on First Floor

The power logger start measurement at 12.00 pm and end at 11:20 am for 24 hours. Therefore the analysis will begin from the next day, which is Thursday due to complete one day visualization of power consumption. The peak hours for a day occur 12:00 pm to 13:00 pm. Meanwhile, the peak hour for next day are expected to occur at 8:00 am to 8:30 am. In addition, the air-conditioning are off after 5:00 pm and will be turn on at 8:00 am every week day. Figure 4-9 shows the power performance of AHU system on first floor area.

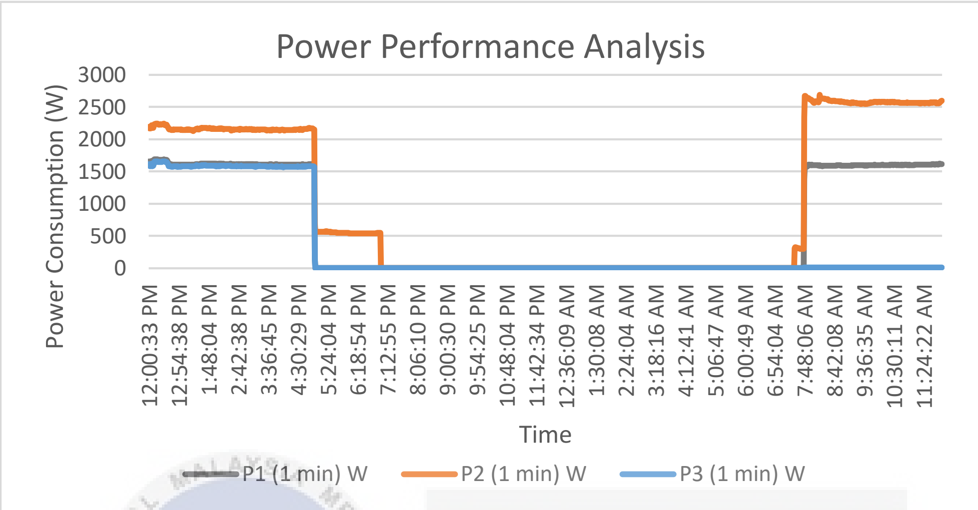

Figure 4-9: Power Performance AHU System on First Floor for One Day

Table 4-9: Data of Power Consumption for One day of First Floor

Date	**Starting time of high power consumption**	**End time of high power consumption**	**Time of the highest power consumption**
7/5/2019	08:00	18:30	12:00-13:00
			08:00-08:30

Table 4-9 shows data of power consumption at first floor. Peak hour occur during 12:00 am because of sunlight exposes in noon. Sunlight expose heat and transfer to the building. When the temperature is high, a compressor of air-conditioning does not expel enough heat from the system and it is forced to run constantly trying to cool the space. This result will adjusted to energy saving how to low the energy consumption.

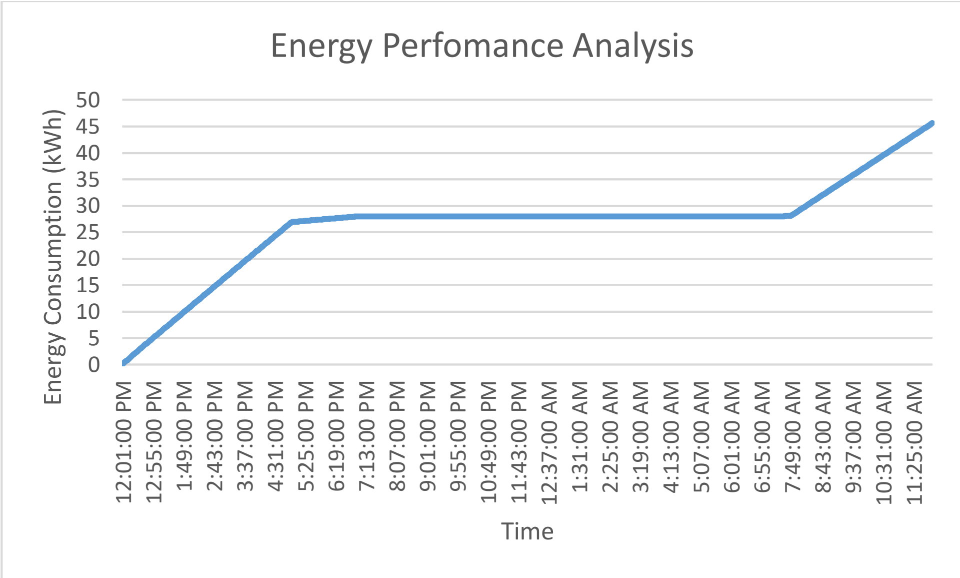

Figure 4-10: Energy Performance AHU System on First Floor

The pattern of this graph show it is increasing slightly during the day compare to the night. The energy consumption is consumed more during the day and the graph shows constant when at the night.

4.4.3 Temperature Level Data

The temperature level data is the information of intensity temperature measurement by using temperature meter equipment refer to methodology. The colour of Table 4-10 for each result show the result of temperature level for the certain area. For the red colour show the area temperature level are hot while the green colour show the accepted level after being compare with Malaysia Standard (MS1525). Next, the blue colour are the temperature in cold level which is under the acceptable temperature range.

Table 4-10: Class of Temperature Level Data

Hot	Accepted	Cold

Table 4-11, Table 4-12 and Table 4-13 shows the result of temperature test on ground floor block A, block B and block C at the Admin Block. Most of the temperature level are accepted with range between temperatures of Malaysia Standard. For Table 4-11, there are four (4) rooms are over temperature level, one (1) rooms consist of under temperature level and other which are three (3) rooms are in accepted level. While in Table 4-12 are the temperature level for ground floor at block B. The table shows the result four (4) rooms are accepted temperature level, four (4) rooms over temperature level and only one under accepted level. Then Table 4-13 prove that there are four (4) room that has over temperature limit, one (1) room only for the below temperature standard level and the other are in accepted level for ground floor of block C.

Table 4-11 Temperature measurement result in ground floor block A at Admin Block

ROOM	Temperature (℃)	Malaysia Standard (℃)
Bilik Kuliah 2	28.7	24-26
Tandas Lelaki	29.5	
Tandas Perempuan	30.0	
Koridor Tengah 1	25.1	
Koridor Tengah 2	26.2	
Bilik Pensyarah (6)	24.1	
Bilik Profesor Madya (6)	24.0	
Bilik Profesor (3)	23.7	

Table 4-12 Temperature measurement result in ground floor block B at Admin Block

Room	Temperature (℃)	Malaysia Standard (℃)
Bilik Pensyarah (6)	24.3	24-26
Bilik Profesor (5)	23.9	
Bilik Profesor Madya (4)	24.3	
Ruang Tangga	27.6	
Bilik Kuliah 1	27.9	
Tandas Lelaki	27.8	
Tandas Perempuan	28.1	
Koridor Tengah 1	25.5	
Koridor Tengah 2	25.9	

Table 4-13 Temperature measurement result in ground floor block C at Admin Block

Room	Temperature (℃)	Malaysia Standard (℃)
Bilik Elektrik	28.1	24-26
Tandas Perempuan	27.8	
Tandas Lelaki	27.3	
Tandas OKU	25.1	
Unit Akademik	23.2	
Pegion Hole	24.2	
Bilik Server	25.1	
Bilik Comrack	25.6	
Tangga	27.5	
Bilik Telefon	24.1	
Stor	24.3	
Ruang Lobi	24.8	

Table 4-14 are the temperature measurement result for the first floor in block A. From the result, most of Bilik Pensyarah are in the comfortable temperature followed the Malaysia Standard. While both toilet male and woman has the temperature level highest than the range of standard. For Table 4-15, the temperature level for block B second floor, corridor and toilet have highest level of temperature than the standard level. In Table 4-16, most of the room around eleven (11) rooms are in suitable temperature. Only the staircase and pantry area, there are an open door and window so that the air conditioning should supply an excessive energy consumption and lead to the increasing of bill and energy consumption. There are seven (7) rooms that below temperature standard level and most of the lecturer rooms are acceptable temperature level.

Table 4-14: Temperature measurement result in first floor block A at Admin Block

Room	Temperature (℃)	Malaysia Standard (℃)
Bilik Pensyarah (6)	24.2	24-26
Bilik Profesor Madya (5)	24.3	
Bilik Profesor (4)	23.6	
Ruang Tangga	26.2	
Bilik Seminar 1	25.4	

Bilik Sembahyang	24.2	
Tandas Lelaki	28.9	
Tandas Perempuan	29.3	
Koridor Tengah 1	25.5	
Koridor Tengah 2	25.3	

Table 4-15: Temperature measurement result in first floor block B at Admin Block

Room	**Temperature (℃)**	**Malaysia Standard (℃)**
Ruang Tangga	27.8	24-26
Bilik Kaunselor Pelajar	25.2	
Bilik Bincang 1	24.5	
Tandas Lelaki	27.7	
Tandas Perempuan	27.8	
Koridor Tengah 1	25.0	
Koridor Tengah 2	28.7	
Bilik Pensyarah (6)	24.5	
Bilik Profesor (6)	23.7	
Bilik Profesor Madya (4)	24	

Table 4-16: Temperature measurement result in first floor block C at Admin Block

Room	**Temperature (℃)**	**Malaysia Standard (℃)**
Tangga	27.8	24-26
Bilik KPP	24.5	
Bilik Ketua Jabatan 1	24.3	
Bilik Ketua Jabatan 2	24.6	
Pantry	27.2	
Bilik Riser	23.7	
Bilik Telefon	23.9	
Tandas Perempuan	27.6	
Tandas Lelaki	27.9	
Bilik Kebal 1	24.2	
Bilik Kebal 2	24.3	
Bilik Fail Pelajar	24.1	
Bilik Timbalan Dekan (A)	24.5	

Bilik Dekan	24.1	
Bilik Timbalan Dekan (PS)	24.2	
Bilik PP	23.9	
Bilik Ketua Jabatan	23.8	
Bilik Ketua Jabatan 2	23.7	
Comrack	24.5	
Ruang Lobi	24.9	
Ruang Legar	23.7	

For the second floor, Table 4-17 are the temperature measurement for block A. Only one six (6) rooms of Bilik Pensyarah are under the temperature level. The rest for three (3) area are in highest temperature level and most of the room temperature has acceptable temperature level. For block B, Table 4-18 shows most of all the rooms are followed the Malaysia Standard range and there have only less number of rooms are under the temperature standard level. For Table 4-19, the result show that the three (3) area which is toilet and the staircase has an excessive level of temperature even most of the temperature are acceptable measurement there still have a corridor that almost to split out from the standard range. It is because of the window are not tinted.

Table 4-17: Temperature measurement result in second floor block A at Admin Block

Room	**Temperature (℃)**	**Malaysia Standard (℃)**
Bilik Pensyarah (6)	23.6	24-26
Ruang Tangga	27.2	
Bilik Profesor (4)	24.1	
Bilik Profesor Madya (6)	24.4	
Bilik Seminar 2	25.4	
Tandas Lelaki	27.3	
Tandas Perempuan	27.8	
Koridor Tengah 1	25.3	
Koridor Tengah 2	25.9	

Table 4-18: Temperature measurement result in second floor block B at Admin Block

Room	Temperature (℃)	Malaysia Standard (℃)
Bilik Pensyarah (6)	23.4	24-26
Bilik Profesor (6)	24.5	
Bilik Profesor Madya (4)	24.3	
Bilik Bincang 2	24.5	
Tandas Lelaki	26.7	
Tandas Perempuan	26.9	
Koridor Tengah 1	24.4	
Koridor Tengah 2	24.6	

Table 4-19: Temperature measurement result in second floor block C at Admin Block

Room	Temperature (℃)	Malaysia Standard (℃)
Tangga	27.1	24-26
Bilik Riser	25.4	
Bilik Telefon	24.2	
Tandas Perempuan	27.8	
Tandas Lelaki	28.1	
Pantri	24.3	
Bilik Fail (BEKM & BEKP)	24.3	
Bilik Mesyuarat	26.5	
Bilik Fail Subjek	24.2	
Bilik Akreditasi	24.1	
Comrack	23.8	
Ruang Menunggu	24.2	
Bilik Fail BEKC	24.5	

There is three table which is Table 4-20, Table 4-21 and Table 4-22 that show the result of temperature measurement compared with the Malaysia Standard temperature level. From the comparison, the result could be analyze and make a group within range of under level, acceptable level and above temperature level. Table 4.16 show that most of Bilik Profesor and Bilik Profesor Madya are under temperature level, toilet and corridor are higher than range of standard level while the rest are in acceptable level. It is because of most of the window are not tinted yet plus the window are opened. So that, this directly affects the functioning of the central air conditioning unit as it would need to increase its effort to overcome the extra losses. Table 4.17, most of the rooms at third floor block C are in acceptable level and only Bilik Pensyarah, Bilik Profesor and Bilik Comrack are under standard temperature measurement.

Table 4-20 Temperature measurement result in third floor block A at Admin Block

Room	**Temperature (℃)**	**Malaysia Standard (℃)**
Bilik Pensyarah (6)	24	24-26
Bilik Profesor (4)	23.9	
Bilik Profesor Madya (6)	23.7	
Tandas Lelaki	27.2	
Tandas Perempuan	27.5	
Koridor Tengah 1	25.7	
Koridor Tengah 2	26.3	
Ruang Tangga	28.2	

Table 4-21: Temperature measurement result in third floor block B at Admin Block

Room	**Temperature (℃)**	**Malaysia Standard (℃)**
Pusat Sumber	24.2	24-26
Bilik Riser	25.1	
Bilik Telefon	24.3	
Tandas Perempuan	27.6	
Tandas Lelaki	26.8	
Bilik Sembahyang	23.8	
Bilik Tuto (L)	24.8	
Bilik Tuto (P)	24.7	
Comrack	23.7	
Bilik Profesor	24.3	
Koridor	27.6	
Tangga	27.1	

Table 4-22: Temperature measurement result in third floor block C at Admin Block

Room	**Temperature (℃)**	**Malaysia Standard (℃)**
Bilik Pensyarah (6)	23.4	24-26
Bilik Profesor (6)	23.8	
Bilik Profesor Madya (4)	24.3	
Tandas Lelaki	27.9	
Tandas Perempuan	27.6	
Koridor Tengah 1	24.3	
Koridor Tengah 2	27.1	
Ruang Tangga	27.8	

4.4.4 Summary of Central Air-Conditioning System

Central air-conditioning system commonly is the highest energy consumption among the loads in admin building. So that, if there is any reduction in this air-conditioning system would give a huge number of reduction and a positive result in cost and energy consumption. Figure 4-11 shows the monthly energy and cost consumption of air conditioning central system.

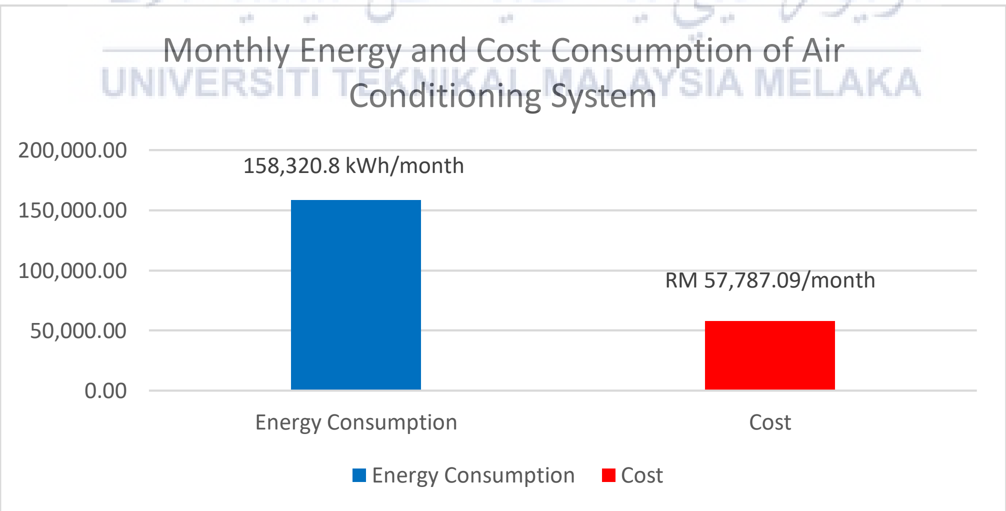

Figure 4-11: Monthly Energy and Cost Consumption

4.4.5 Energy Saving Strategy for Air-Conditioning Central System

Air-Conditioning central system in Admin Block have consumed 72 % of the total loads. Energy and cost reduction in this section is expected to give a huge impact for energy consumption and energy cost. The suggestion of energy saving strategy for air conditioning are operating time scheduling (AHU), reduce daily air conditioning operating temperature and installing window films.

(a) Operating Time Scheduling (AHU)

This part focuses on Air Handling Unit system which is one part of the indoor unit of air conditioning central system. There are two units of AHU for every level of admin block at FKE. Table 4-23 below are the time table of current schedule of AHU.

Table 4-23: Current Schedule of AHU

AHU No.	Ground Floor		1st Floor		2nd Floor		3rd Floor	
	A	B	A	B	A	B	A	B
Monday	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00
Tuesday	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00
Wednesday	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00
Thursday	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00
Friday	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00	08:00-17:00

There is each AHU is being used to supply cooled air for block A, B and C. As shows in Table 4-23, all AHU have used the operating time, which is from 8.00 am to 5.00 pm. Motors that start at the same time can lead to increase of maximum demand. So that, when start AHU on the different time operating can reduce the maximum demand and reduce the energy consumption. Therefore, time for AHU for ground floor can be reduced by start the operating time at 8:30 am to 4:30 pm because on ground floor there have Bilik Kuliah 1 (BK1) and Bilik Kuliah 2 (BK2) and most of the class start on 8.30 am and end at 4.00 pm. The time table are shown in Table 4-24.

For AHU on first floor, most of the room are consist lecturer room, seminar room and academic unit. Most of the time, on the lunch hour there is no people in admin block therefore there have wasted operating time. Excessive operating of AHU can be reduced to save more energy consumption and cost. The new operating time for AHU on first floor is shown in Table 4-24.

Next, AHU on second floor and third floor there is more room that not have been used for 9 hours straight such as Bilik Tutor 1, Bilik Tutor 2, Pusat Sumber and more. In addition, most of the lecturer room are not used anymore either they are leave for study, moving out to the ground floor and other reason. The operating time can be minimized with start the AHU 30 minutes late and 30 minutes early from usual. Then, off AHU during lunch hour. New schedule for AHU second and third floor is shown in Table 4-24.

Table 4-24: New Schedule of Operating Time AHU

AHU No.	Ground Floor		1st Floor		2nd Floor		3rd Floor	
	A	B	A	B	A	B	A	B
Monday	08:30-16:30	08:30-16:30	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30
Tuesday	08:30-16:30	08:30-16:30	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30
Wednesday	08:30-16:30	08:30-16:30	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30
Thursday	08:30-16:30	08:30-16:30	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30
Friday	08:30-16:30	08:30-16:30	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-17:00	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30	08:30-12:00 and 14:00-16:30

Saved Time (hours/month)	**20 hours**	**20 hours**	**46 hours**	**46 hours**	**60 hours**	**60 hours**	**60 hours**	**60 hours**

$$Energy\ Saving = Saved\ Time\ \left(\frac{hours}{month}\right) \times Power\ of\ AHU\ (kW) \quad (4.1)$$

$$Cost\ Saving = Energy\ Saving \times Tariff\ C1\ rate \quad (4.2)$$

By using both the formula (4.1) and (4.2) above, the energy saving and cost saving can be calculated. The calculation are as below:

a) Level Ground Floor (A, B)

Power (kW) = 208.91 kW

$Energy\ Saving = 208.91 \times 20$

$= 4178.2\ kW$

$Cost\ Saving = 4178.2 \times 0.365$

$= RM\ 1525.04$

b) Level 1st Floor (A, B)

Power (kW) = 240.21 kW

$Energy\ Saving = 240.21 \times 46$

$= 11049.66\ kW$

$Cost\ Saving = 11049.66 \times 0.365$

$= RM\ 4033.13$

c) Level 2nd Floor (A, B)

Power (kW) = 219.07 kW

$Energy\ Saving = 219.07 \times 60$

$= 13144.2\ kW$

$Cost\ Saving = 13144.2 \times 0.365$

$= RM\ 4797.63$

d) Level 3rd Floor (A, B)

Power (kW) = 211.37 kW

$$Energy\ Saving = 211.37 \times 60$$
$$= 12682.2\ kW$$
$$Cost\ Saving = 12682.2 \times 0.365$$
$$= RM\ 4629.00$$

Table 4-25: Energy Saving and Cost Saving for AHU

AHU No.	Ground Floor	1st Floor	2nd Floor	3rd Floor
	(A, B)	(A, B)	(A, B)	(A, B)
Energy Saving (kWh/month)	4178.20	11049.66	13144.20	12682.2
Cost Saving (RM/month)	1525.04	4013.13	4797.63	4629.00

Based on Table 4-25 above, total saving for operating time scheduling is 41,054.26 kWh/month and RM 14,964.80 monthly.

(b) Reduce Daily Air-Conditioning Central System Operating Temperature

The air-conditioning system is operating 9 hours a day in office hour for a week. Further savings could be achieve if the operation of temperature air-conditioning system set to be range 24-26 degree. With this reduction of air-conditioning temperature, this could translate to annual savings of air-conditioning. From analysis of energy efficiency at Airport of Kota Kinabalu [29], it shows that the estimation of energy saving of the reducing air-conditioning temperature could be saved to 8% from the total energy consumption of air-conditioning system.

Figure 4-12 shows the room temperature of Admin Block after the reduction of air-conditioning temperature followed the Malaysia Standard (MS1525). The red line are the group of standard temperature range between 24˚C to 26℃ that apply in the each room of Admin Block. Therefore, the result of the percentage room of temperature are shown in Figure 4-13.

For the Table 4-26, the data prove that the energy saving and cost saving after the reducing of air-conditioning temperature. It does not invest any amount of budget to implement the energy saving management therefore there is no payback period for this energy saving measures.

Figure 4-12: Room Temperature of Admin Block

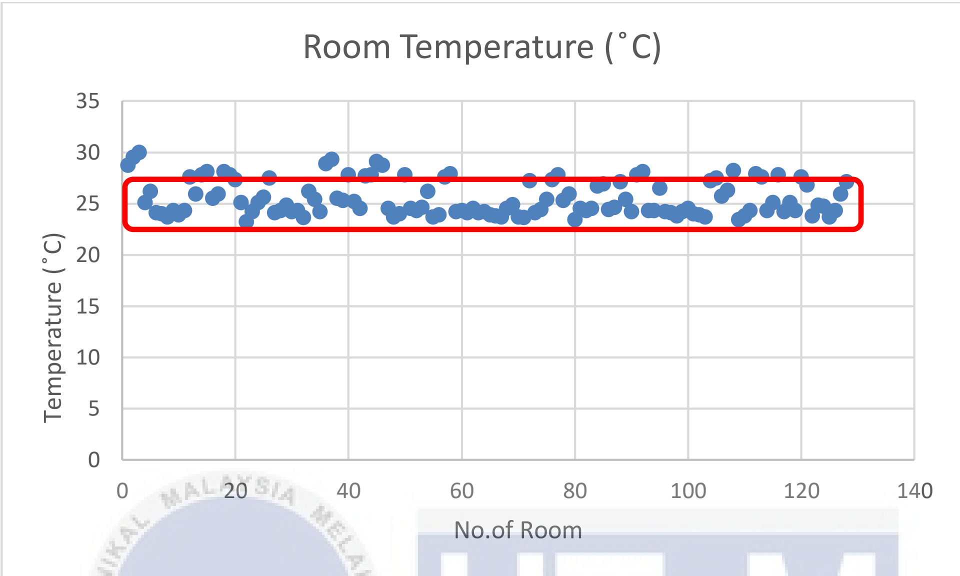

Figure 4-13: Percentage Room of Temperature

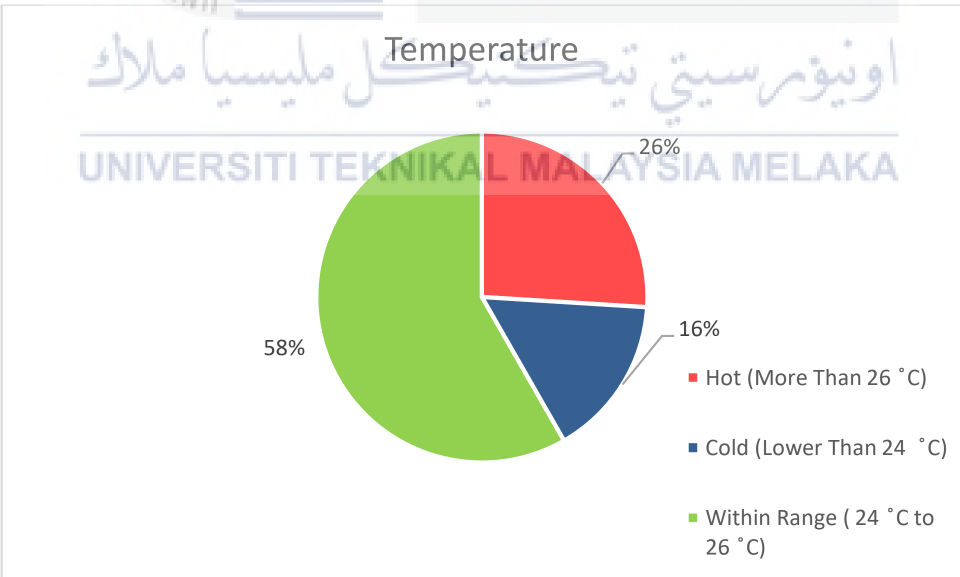

Table 4-26: Reduce Daily Air-Conditioning System Operating Temperature

Tariff Rate	0.365	RM/kWh
MD	30.30	RW/kW

Estimated Savings	8%	
Load %	72%	
Energy Consumption by Air-Conditioning	158,320.8	kWh

No	Item	Amount
1	Monthly Energy Consumption (kWh/month)	144,735.14
2	Monthly Energy Cost (RM/month)	52,828.32
3	Monthly Energy Saving (kWh/month)	13,585.66
4	Monthly Energy Cost Saving (RM/month)	4,958.77
5	Investment (RM)	-
6	Payback Period (month)	-

(c) Install the Split Unit of Air-Conditioning

The commercial building that used the central air-conditioning system for the whole building usually circulate cool air through a system of supply to the all rooms even though there is no people occupant in that rooms. For the area such as Bilik Kuliah 1, Bilik Kuliah 2, Bilik Seminar 1 and Bilik Seminar 2, the student that used the class only when there is the lecture session based on the class schedule. If there is no lecture, the room are empty and there are a wasting energy consumption of air-conditioning. Therefore, by using the split unit at all the lecture room such Bilik Kuliah 1, Bilik Kuliah 2, Bilik Seminar 1, Bilik Seminar 2 and Bilik Tuto, the energy consumption can be controlled by switching on and off the split unit air conditioning.

For more effective way, install the split system air conditioner with the energy saving label from Suruhanjaya Tenaga Malaysia (ST). Choosing an air conditioning system is an important decision. A poor choice may be costly to purchase and operate and yet fail to provide the desired cooling comfort. The cooling power needs of slip unit system air conditioning are based on the area of the room. Table 4-27 show the air conditioners horsepower based on room’s floor area.

Table 4-27: The Air Conditioners Horsepower Based on Room's Floor Area.

Floor Area (m^2)	AC Unit Size (HP)
10.5	0.5
11-14	0.75
15-21	1.0
22-25	1.5
26-28	2.0
39-48	2.5

Table 4-28 Information of Split-Unit Air Conditioner

Area	Gross Floor Area(m^2)	No.Unit	AC Unit Size (Hp)	Power (W)
Bilik Kuliah 1	79.35	2	2.5	3,730
Bilik Kuliah 2	79.35	2	2.5	3,730
Bilik Seminar 1	102.35	2	2.5	3,730
Bilik Seminar 2	69.00	2	2.5	3,730
Bilik Tuto 1	40.88	1	2.5	1,865
Bilik Tuto 2	40.88	1	2.5	1,865
			Total	18,650

$$Monthly\ energy\ saving = 3{,}357 kWh/month$$
$$= 158{,}320.8 - 3{,}357$$
$$= 154{,}963.8\ kWh/month$$

$$Monthly\ cost\ saving = 154{,}963.8\ \times 0.365 = RM\ 56{,}561.79/month$$

$$The\ cost\ installation = RM2328 \times 10 = RM23{,}280$$

$$Payback\ Period = \frac{Cost\ of\ Installation}{Monthly\ Bill\ Payment\ Saving}$$
$$= \frac{RM\ 23{,}280}{RM\ 56{,}561.79}$$
$$= 0.41\ months$$

(d) Air-Conditioner Cleaning

Each level consist of two unit of AHU. When visiting all of AHU unit for logger metre, AHU equipment has been inspection to check any factor that increasing the air-conditioner's energy consumption of each level. One factor of increasing energy consumption are the dirty air filter. From figure below, it is show that AHU air filter full with dust. The dirty filters restrict airflow and reduce efficiency. From survey with Encik Luqman, a mechanical engineer at Pejabat Pembangunan said that cleaning air filter AHU does not have any cost of cleaning. But the cleaning part only used manpower to clean each air filter of AHU.

Figure 4-14: AHU air filter

By cleaning the filter regularly can maximize the unit's cooling potential. One of study from U.S Department of Energy [30] says the reduction of air conditioner's energy consumption by as much as 15%.

$$\begin{aligned} Monthly\ Energy\ Saving &= Total\ Air - Conditioning\ Energy\ \times 15\% \\ &= 158{,}320.8\ \times 15\% \\ &= 134{,}572.68\ kWh/month \end{aligned}$$

$$\begin{aligned} Monthly\ Cost\ Saving &= Energy\ Saving\ \times Tariff\ C1\ Rate \\ &= 134{,}572.68\ kWh/month \times RM\ 0.365 \\ &= RM\ 49{,}119.03\ /months \end{aligned}$$

4.4.6 Monthly Air-Conditioning Central System Energy and Cost Comparison

The proposed energy saving strategy split the graph to two graph, one for monthly air-conditioning energy consumption and another one for monthly air-conditioning cost consumption. Figure 4-15 and Figure 4-16 shows the monthly air-conditioning energy and cost consumption comparison after energy saving strategy has been proposed. Each energy saving strategy have different rate of percentage energy saving. For new schedule AHU, it reduce to 25.93% and by reducing temperature the reduction of energy consumption are 8%. While by installing split unit air-conditioner at certain room that use by students, there is does not have so much different. It only can reduce the energy and cost by 2.48%. Last but not least, by cleaning air conditioning, it can reduce at 15% monthly.

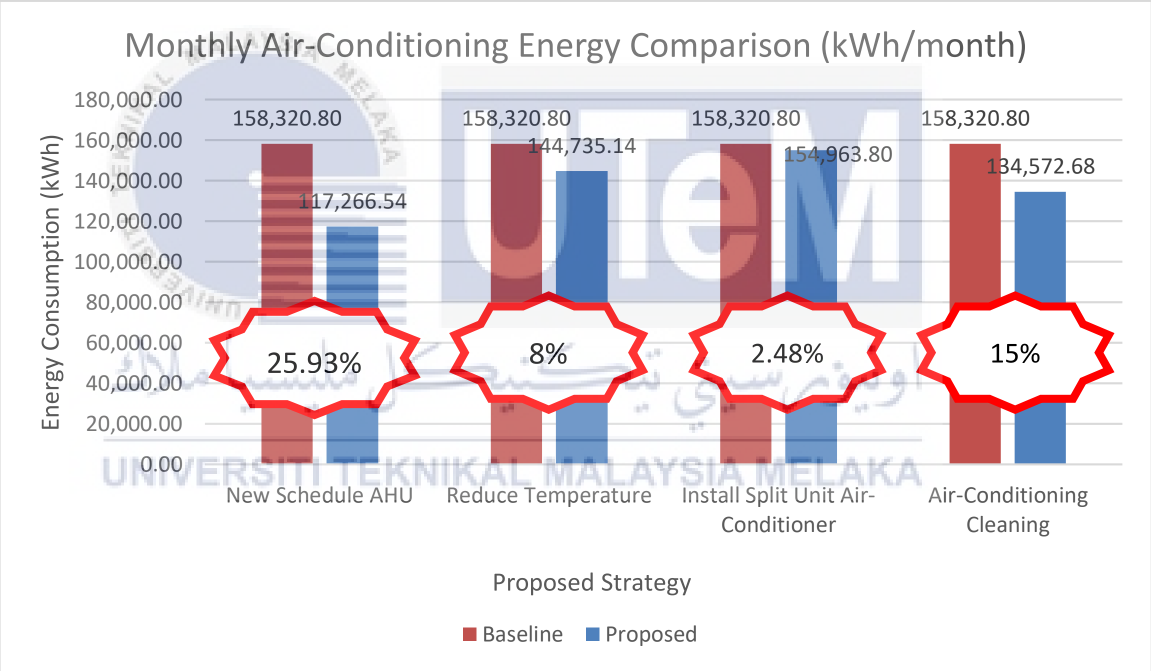

Figure 4-15: Monthly Air-Conditioning Energy Comparison

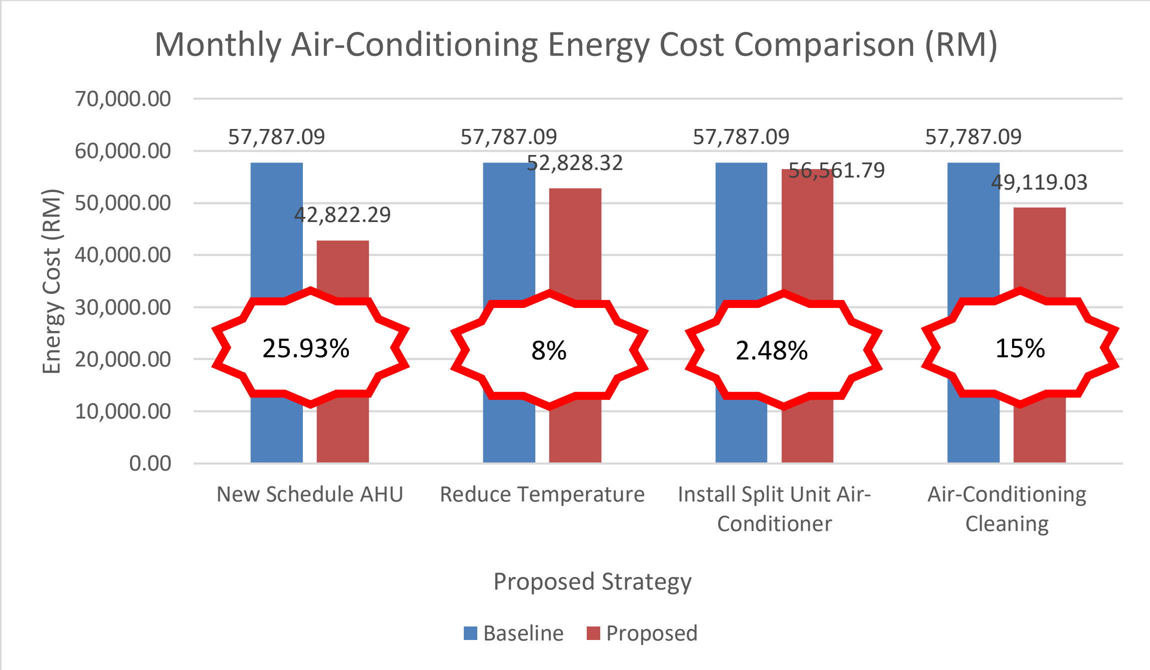

Figure 4-16: Monthly Air-Conditioning Energy Cost Comparison

4.5 Lighting

Most of the lamp type fitting in the Admin Block, found that it is fluorescent lamp by two (2) feet and four (4) feet. There is also LED with two (2) feet. The energy consumption was collected room by room with calculated each lamp found in the rooms. From Lux test, the luminance level is not consisted since some area follows the standard and vice versa. The lighting schematic drawing can be seen in the result. Figure 4-17, Figure 4-18, Figure 4-19 and Figure 4-20 shows there are several type installation of lighting with different brand, feet and luminaires at Admin Block.

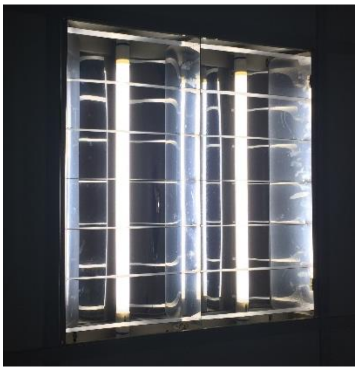

Figure 4-17 $2 \times 10W$ T8 LED Philips Light

Figure 4-18 $4 \times 18W$ T8 Fluorescent DAVIS Light

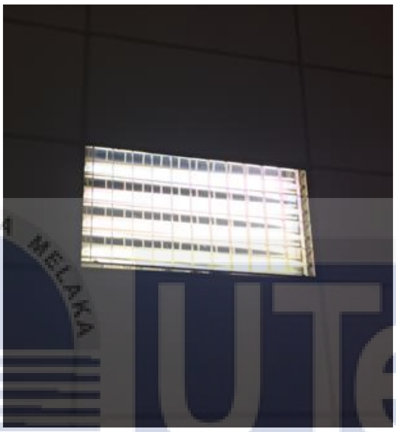

Figure 4-19 $3 \times 36W$ T8 Fluorescent DAVIS Light

Figure 4-20 $1 \times 13W$ T5 Fluorescent Exit Sign Light

4.5.1 Energy Consumption for Lighting System

Data of lighting was collected with the work site survey to the each level in Admin Block. From the survey, the data of lamp's feet, number of each casing, number of lamp for each casing, power of lamp, number of ballast for each casing and power of ballast are show as in Table 4-29, Table 4-30, Table 4-31 and Table 4-32. From the result, fluorescent light are the most commonly type of lighting that have been used. There are some reason why LED does not need a ballast. It is because of LED use direct current (DC) and also it is use a driver which function same with ballast. The fluorescent light that available in two wattages which is 36W and 18W for 4 feet and 2 feet. Usually , one lamp consist of one ballast but for admin block the lighting circuit can be minimize the number of ballast for all lamp in each casing.

Table 4-29: Power Consumption of Lighting at Level Ground

ROOM	Type of Lamp	Lamp's Feet	No of Lamps	Lamps Watt (W)	No of Ballast	Ballast Watt (W)	Total Power (W)
Bilik AHU (2)	Fluorescent	4	6	36	6	40	912
Bilik Pensyarah (30)	Fluorescent	4	6	36	6	40	13,680
Ruang Tangga (2)	Fluorescent	2	8	18	4	40	608
Koridor Luar (3)	Fluorescent	2	8	18	4	40	912
Bilik Kuliah (2)	Fluorescent	4	24	36	24	40	3648
Tandas Lelaki (3)	Fluorescent	2	4	18	2	40	456
Tandas Perempuan (3)	Fluorescent	2	4	18	2	40	456
Tandas OKU (1)	Fluorescent	2	4	18	2	40	152
Koridor Tengah (2)	Fluorescent	4	4	36	2	40	448
	LED	2	24	10	-	-	480

Lampu Kecemasan (3)	Fluorescent	1	13	13	-	-	507
Lampu Keluar (3)	Fluorescent	2	6	18	-	-	324
Bilik Elektrik (1)	Fluorescent	2	6	18	3	40	228
Unit Akademik (1)	Fluorescent	2	12	18	12	40	696
Pegion Hole (1)	LED	2	8	10	-	-	80
Bilik Server (1)	Fluorescent	4	12	36	12	40	912
Bilik Comrack(1)	Fluorescent	4	4	36	4	40	304
Tangga(1)	Fluorescent	2	8	18	2	40	224
Bilik Telefon (1)	Fluorescent	2	2	18	1	40	76
Stor (1)	Fluorescent	4	2	36	2	40	152
Ruang Lobby(1)	LED	2	92	10	-	-	920

Table 4-30: Power Consumption of Lighting at Level 1

ROOM	Type of Lamp	Lamp's Feet	No of Lamps	Lamps Watt (W)	No of Ballast	Ballast Watt (W)	Total Power (W)
Bilik AHU (2)	Fluorescent	4	6	36	6	40	912
Bilik Pensyarah (32)	Fluorescent	4	6	36	6	40	14592

Ruang Tangga (2)	Fluorescent	2	8	18	4	40	608
Bilik Seminar (1)	Fluorescent	4	24	36	24	40	1864
Tandas Lelaki (3)	Fluorescent	2	4	18	2	40	456
Tandas Perempuan (3)	Fluorescent	2	4	18	2	40	456
Koridor Tengah (2)	Fluorescent	2	4	18	2	40	304
	LED	2	24	10	-	-	240
Lampu Kecemasan (3)	Fluorescent	1	13	13	-	-	507
Lampu Keluar (3)	Fluorescent	2	4	8	-	-	108
Bilik Kaunselor Pelajar (1)	Fluorescent	4	9	36	9	40	684
Bilik Bincang 1	Fluorescent	4	18	36	18	40	1368
Tangga (1)	Fluorescent	2	8	18	4	40	304
Bilik KPP(1)	Fluorescent	4	6	36	6	40	456
Bilik Ketua Jabatan (2)	Fluorescent	4	6	36	6	40	912
Pantry(1)	Fluorescent	2	8	18	4	40	204
Bilik Riser(1)	Fluorescent	4	2	36	2	40	152
Bilik Telefon(1)	Fluorescent	2	2	36	1	40	112

Bilik Kebal (2)	Fluorescent	4	6	36	6	40	912
Bilik Fail Pelajar(1)	Fluorescent	4	6	36	6	40	456
Bilik Timbalan Dekan (2)	Fluorescent	4	9	36	9	40	1368
Bilik Dekan (1)	Fluorescent	4	8	36	8	40	608
Bilik PP (1)	Fluorescent	4	6	36	4	40	376
	Fluorescent	2	2	18	1	40	76
Bilik Ketua Jabatan (2)	Fluorescent	4	6	36	6	40	912
Comrack (1)	Fluorescent	4	4	36	4	40	304
Ruang Lobi(1)	Fluorescent	4	36	36	36	40	2736
	Fluorescent	2	4	18	2	40	152
Ruang Legar (1)	LED	4	4	18	-	-	72

Table 4-31: Power Consumption of Lighting at Level 2

ROOM	Type of Lamp	Lamp's Feet	No of Lamps	Lamps Watt (W)	No of Ballast	Ballast Watt (W)	Total Power (W)
Bilik AHU (2)	Fluorescent	4	6	36	6	40	912
Bilik Pensyarah (32)	Fluorescent	4	6	36	6	40	14592
Ruang Tangga (2)	Fluorescent	2	8	18	8	40	928
Bilik Seminar (1)	Fluorescent	2	20	36	20	40	1520

Tandas Lelaki (3)	Fluorescent	2	4	18	2	40	456
Tandas Perempuan (3)	Fluorescent	2	4	18	2	40	456
Koridor Tengah (2)	Fluorescent	2	4	18	2	40	304
	LED	2	32	10	-	-	320
Lampu Kecemasan (3)	Fluorescent	1	13	13	-	-	507
Lampu Keluar (3)	Fluorescent	2	5	8	-	-	120
Bilik Bincang (1)	Fluorescent	4	27	36	27	40	2052
Tangga (1)	Fluorescent	2	8	18	4	40	304
Bilik Riser (1)	Fluorescent	4	2	36	2	40	152
Bilik Telefon (1)	Fluorescent	2	2	18	1	40	76
Pantri (1)	Fluorescent	2	4	18	2	40	152
Bilik Fail (1)	Fluorescent	4	6	36	6	40	456
Bilik Mesyuarat (1)	Fluorescent	4	36	36	36	40	2736
	Fluorescent	2	38	18	19	40	1444
Bilik Fail Subjek (1)	Fluorescent	4	6	36	6	40	456
Bilik Akreditasi (1)	Fluorescent	4	6	36	6	40	456
Comrack (1)	Fluorescent	4	4	36	4	40	304
Ruang Menunggu (1)	LED	2	50	10	-	-	500
Bilik Fail BEKC (1)	Fluorescent	4	2	36	6	40	312

Table 4-32: Power Consumption of Lighting at Level 3

ROOM	Type of Lamp	Lamp's Feet	No of Lamps	Lamps Watt (W)	No of Ballast	Ballast Watt (W)	Total Power (W)
Bilik AHU (2)	Fluorescent	4	6	36	6	40	912
Bilik Pensyarah (33)	Fluorescent	4	6	36	6	40	15048
Ruang Tangga (2)	Fluorescent	2	4	18	2	40	304
Tandas Lelaki (3)	Fluorescent	2	4	18	2	40	456
Tandas Perempuan (3)	Fluorescent	2	4	18	2	40	456
Koridor Tengah (2)	Fluorescent	2	4	18	2	40	304
	LED	2	32	10	-	-	320
Lampu Kecemasan (3)	Fluorescent	1	8	13	-	-	312
Lampu Keluar (3)	Fluorescent	2	3	8	-	-	72
Tangga (1)	Fluorescent	2	8	18	4	40	304
Bilik Riser (1)	Fluorescent	4	2	36	2	40	152
Bilik Telefon (1)	Fluorescent	2	2	18	1	40	76
Pusat Sumber(1)	Fluorescent	4	24	36	24	40	1824
Bilik Sembahyang (1)	Fluorescent	4	9	36	9	40	684
Bilik Tuto L (1)	Fluorescent	4	12	36	12	40	912
Bilik Tuto P(1)	Fluorescent	4	9	36	9	40	684

Comrack (1)	Fluorescent	4	4	36	4	40	304
Koridor (1)	LED	2	32	10	-	-	320

4.5.1.1 Energy Consumption and Cost of Lighting System

a) Power Consumption

Power Consumption of Level Ground (kW)

= 912+13,680+608+912+3648+456+456+152+448+480+507+324+228+696 +80+912+304+224+76+152+920

=26,175 W

=26.18 kW

Power Consumption of Level 1 (kW)

= 456+456+304+240+507+108+684+1368+304+456+912+204+152+112 +912+456+1368+608+376+76+912+304+2736+152+72

=14235 W

=14.24 kW

Power Consumption of Level 2

= 912+ 14592+928+1520+456+456+304+320+507+120+2052+304+152+76 +152+456+2736+1444+456+456+304+500+312

= 29515 W

= 29.52 kW

Power Consumption of Level 3

= 912+15048+304+456+456+304+320+312+72+304+152+76+1824+684 +912+684+304+320

= 23444 W

= 23.44 kW

b) Energy Consumption (kWh/month)

Energy Consumption of Level Ground = 26.18 × 9h × 22days

= 5183.64 kW/month

Energy Consumption of Level 1 = 14.24 × 9h × 22days

= 2819.52 kW/month

Energy Consumption of Level 2 = 29.52 × 9h × 22days

= 5844.96 kW/month

Energy Consumption of Level 3 = 23.44 × 9h × 22days

= 4641.12 kW/month

Table 4-33: Summary of Lighting Energy Consumption

Building	Area	Total Power Consumption (kW)	Operating Hours	Energy Consumption (kWh)	Energy Consumption per month (kWh/month)	Cost (RM/month)
Block A, Block B, Block C	Ground Floor	26.18	9	235.62	5,183.64	1,892.03
	First Floor	14.24	9	128.16	2,819.52	1,029.12
	Second Floor	29.52	9	265.68	5,844.96	2,133.41
	Third Floor	23.44	9	210.96	4,641.12	1,694.00
Total		**85.97**		**840.42**	**18,489.24**	**6,748.56**

4.5.2 LUX Level for Admin Block of FKE

By collecting the data, there are a need to be taken into consideration to guarantee the efficiency of lighting is achieved such as the luminance and type of lights that have been utilized. For the lux level data, the reading was taken at the height of the work plane which is about 3m above where the working space. But by theoretical [31], the reading have to be taken at the height 0.8m above the floor. It is all based on the location where is the most area are used to perform the work.

Lux level data are the information of the light measurement in illuminace. It refers to the amount of light falling on a unit area of work surface. The Table below shows the meaning of the colour by block to classify the lux measurement which are under lux area, accepted lux area and over lux area in each of the rooms. The colour which are green, red and blue have been chosen as description of the lux colour

Table 4-34: Colour Indicator for Luminance Level Data

Description	**Under-Lux**	**Accepted-Lux**	**Over-Lux**
Colour			

From Table 4-35 , there are five (5) rooms are in accepted lux level, three (3) rooms are under lux and three (3) rooms are over lux level. Ruang Tangga have an excessive light because the area are located at outdoor area with the door are usually open for the staff and student going in and out to the next floor. It is same goes to the outdoor corridor. In Table 4-36, it show the luminance data of ground floor are for block B. The data prove that most of the room are accepted lux level while the other three (3) rooms are over the standard level with the tolerance more than 10%. Table 4-37 shows the lux level of ground floor for block C area. The results shows there is a wasted lighting energy at lobby so that an excessive luminance effect the energy efficiency. Next, six (6) rooms are accepted level and only three (3) rooms are under lux level.

Table 4-35: Luminance Data on Ground Floor for Block A

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
AHU	125.2	100.1	166.8	130.7	500	-369.3	-73.9
Ruang Tangga	248.9	300.1	320.0	289.7	100	189.7	189.8
Koridor Luar	342.7	360.8	391.5	365.0	100	265.0	265.0
Bilik Kuliah 2	171.5	166.8	188.8	175.7	300	-124.3	-41.4
Tandas Lelaki	48.0	38.5	57.7	48.1	100	-51.9	-51.9
Tandas Perempuan	113.1	112.2	111.3	112.2	100	12.2	12.2
Koridor Tengah 1	236.3	237.3	233.7	235.8	100	135.8	135.8
Koridor Tengah 2	192.1	194.7	192.1	192.9	100	92.9	92.9
Bilik Pensyarah (6)	587.0	585.7	584.6	585.8	300	285.8	95.2
Bilik Profesor Madya (6)	587.0	585.7	584.6	585.8	300	285.8	95.2
Bilik Profesor (3)	473.4	490.3	460.6	474.8	300	174.8	58.2

Table 4-36: Luminance Data on Ground Floor for Block B

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik Pensyarah (6)	283.8	301.5	231.5	272.3	300	-27.7	-9.2
Bilik Profesor (5)	238.4	284.9	261.2	261.5	300	-38.5	-12.8
Bilik Profesor Madya (4)	469.0	313.0	579.0	453.7	300	153.7	51.2

Bilik AHU	125.2	100.1	166.8	130.7	500	-369.3	-73.9
Ruang Tangga	295.6	245.7	237.2	259.5	100	159.5	159.5
Koridor Luar	271.4	244.5	176.1	230.7	100	130.7	130.7
Bilik Kuliah 1	324.2	389.1	376.5	363.3	300	63.3	21.1
Tandas Lelaki	192.0	160.0	105.0	152.3	100	52.3	52.3
Tandas Perempuan	82.3	119.0	178.8	126.7	100	26.7	26.7
Koridor Tengah 1	212.3	136.7	150.2	166.4	100	66.4	66.4
Koridor Tengah 2	211.1	125.4	145.9	160.8	100	60.8	60.8

Table 4-37: Luminance Data on Ground Floor for Block C

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik Elektrik	40.2	21.2	45.6	35.7	150	-114.3	-76.2
Tandas Perempuan	16.0	17.0	49.0	27.3	100	-72.7	-72.7
Tandas Lelaki	35.4	34.7	35.4	35.2	100	-64.8	-64.8
Tandas OKU	181.9	183.4	183.6	183.0	100	83.0	83.0
Unit Akademik	449.5	449.6	448.2	449.1	300	149.1	49.7
Pegion Hole	183.2	172.4	238.0	197.9	150	47.9	31.9
Bilik Server	290.1	220.1	125.3	211.8	150	61.8	41.2
Bilik Comrack	280.0	365.0	200.0	281.7	150	131.7	87.8
Tangga	278.8	269.4	268.1	272.1	100	172.1	172.1
Bilik Telefon	298.1	228.1	245.2	257.1	100	157.1	157.1
Stor	198.2	237.1	216.4	217.2	150	67.2	44.8
Ruang Lobi	272.0	274.0	178.0	241.3	100	141.3	141.3
Koridor Luar 1	325.7	230.0	326.5	294.1	100	194.1	194.1
Koridor Luar 2	241.3	231.0	281.1	251.1	100	151.1	151.1

Table 4-38, Table 4-39 and Table 4-40 are the luminance data for block A, block B and block C. Table 4-38 shows there are four (4) rooms with over lux level, five (5) rooms are accepted lux level and the rest are under lux level. For Bilik Seminar, the lux level are under standard level because some of the lamp are not working anymore and the lamp need the replacement. Since Bilik Seminar are one of the classroom that student and lecturer most of the time are using the class for the lecture. Table 4-39 prove that the central corridor, woman toilet and staircase area are over lux level while all the lecturer rooms are accepted lux level. Other, AHU room and Bilik Bincang 1 are under lux level. Next Table 4-40, it prove that ten (10) rooms are accepted lux level, one (1) room under lux level and to be conclude that most of the rooms are over lux level with the excessive light around the area

Table 4-38 Luminance Data on First Floor for Block A

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik AHU	130.2	123.4	222.1	158.6	500	-341.4	-68.3
Bilik Pensyarah (6)	418.9	562.3	530.1	503.8	300	203.8	67.9
Bilik Profesor Madya (5)	415.1	423.3	390.4	409.6	300	109.6	36.5
Bilik Profesor (4)	273.2	258.6	172.5	234.8	300	-65.2	-21.7
Ruang Tangga	320.4	350.7	378.9	350.0	100	250.0	250.0
Bilik Seminar 1	232.2	241.8	238.9	237.6	300	-62.4	-20.8
Bilik Sembahyang	349.0	421.0	178.0	316.0	300	16.0	5.3
Tandas Lelaki	192.3	160.1	105.2	152.5	100	52.5	52.5
Tandas Perempuan	86.0	153.0	411.0	216.7	100	116.7	116.7
Koridor Tengah 1	279.2	280.1	276.5	278.6	100	178.6	178.6
Koridor Tengah 2	430.1	220.4	325.5	325.3	100	225.3	225.3

Table 4-39 Luminance Data on First Floor for Block B

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik AHU	122.3	71	178.2	123.8	500	-376.2	-75.2
Ruang Tangga	299.3	261.2	243.5	268.0	100	168.0	168.0
Bilik Kaunselor Pelajar	472.3	532.1	339.2	447.9	300	147.9	49.3
Bilik Bincang 1	200.2	290.1	244.5	244.9	300	-55.1	-18.4

Tandas Lelaki	177.8	118.5	243.3	179.9	100	79.9	79.9
Tandas Perempuan	92.1	213.4	411.2	238.9	100	138.9	138.9
Koridor Tengah 1	320.4	244.3	254.3	273.0	100	173.0	173.0
Koridor Tengah 2	443.2	218.7	329.4	330.4	100	230.4	230.4
Bilik Pensyarah (6)	224.5	570.9	173.2	322.9	300	22.9	7.6
Bilik Profesor (6)	338.2	300	433.2	357.1	300	57.1	19.0
Bilik Profesor Madya (4)	412.2	407.9	340.2	386.8	300	86.8	28.9

Table 4-40: Luminance Data on First Floor for Block C

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Tangga	235.2	233.9	234.7	234.6	100	134.6	134.6
Bilik KPP	445.2	432.5	589.7	489.1	300	189.1	63.0
Bilik Ketua Jabatan 1	220.3	564.3	408	397.5	300	97.5	32.5
Bilik Ketua Jabatan 2	540	543.2	632.3	571.8	300	271.8	90.6
Pantry	660.1	820.9	734.6	738.5	150	588.5	392.4
Bilik Riser	290	310	260	286.7	100	186.7	186.7
Bilik Telefon	278.2	322.4	280.9	293.8	100	193.8	193.8
Tandas Perempuan	180.9	223.3	114.5	172.9	100	72.9	72.9
Tandas Lelaki	200	140.5	132.5	157.7	100	57.7	57.7
Bilik Kebal 1	580.2	630.4	475.6	562.1	150	412.1	274.7
Bilik Kebal 2	337.2	451.2	522.1	436.8	150	286.8	191.2
Bilik Fail Pelajar	198.2	625.4	289.2	370.9	150	220.9	147.3
Bilik Timbalan Dekan (A)	408.1	460.4	720.8	529.8	300	229.8	76.6

Bilik Dekan	170	540.2	400.2	370.1	300	70.1	23.4
Bilik Timbalan Dekan (PS)	410.2	443.4	680.2	511.3	300	211.3	70.4
Bilik PP	258.4	260.8	259.8	259.7	300	-40.3	-13.4
Bilik Ketua Jabatan	530.2	446.3	345.2	440.6	300	140.6	46.9
Bilik Ketua Jabatan 2	210.3	370.2	310.1	296.9	300	-3.1	-1.0
Comrack	320.1	240.3	253.1	271.2	100	171.2	171.2
Ruang Lobi	331.5	344.5	329.7	335.2	100	235.2	235.2
Ruang Legar	473.2	345.1	538.9	452.4	300	152.4	50.8
Lif	251.4	251.6	249.9	251.0	100	151.0	151.0

Table 4-41, Table 4-42 and Table 4-43 are the information of lux level for the second floor of block A, block B and block C. Table 4-41 shows the five (5) rooms are accepted lux level, three (3) rooms in over lux level and two (2) rooms are under lux level. All of this lux level have been compared with Malaysia Standard level which is MS 1525. For Table 4-42, the results are four (4) rooms are under lux level which are AHU room, Bilik Pensyarah and both toilet. For the accepted lux level, three (3) rooms and one (1) central corridor. The central corridor 2, which are nearest to the window that not has been tinted yet and the daylight are excess through the window so that the area have highest illuminace than other area. For Table 4-43, it can be conclude that most of the area are excessive with light which are over lux level. While four (4) rooms are accepted level and only two (2) area are under lux level.

Table 4-41: Luminance Data on Second Floor for Block A

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik AHU	130.2	84.2	196.1	136.8	500	-363.2	-72.6
Bilik Pensyarah (6)	365.4	224.3	480.2	356.6	300	56.6	18.9
Ruang Tangga	345	291	343	326.3	100	226.3	226.3
Bilik Profesor (4)	644.5	582.2	523.3	583.3	300	283.3	94.4
Bilik Profesor Madya (6)	341.2	350.3	298.5	330.0	300	30.0	10.0
Bilik Seminar 2	209.1	700.1	240.1	383.1	300	83.1	27.7
Tandas Lelaki	59.2	97.3	88.2	81.6	100	-18.4	-18.4
Tandas Perempuan	127.4	129.5	127.5	128.1	100	28.1	28.1
Koridor Tengah 1	279.2	280.3	279.1	279.5	100	179.5	179.5
Koridor Tengah 2	355.2	324.5	360.1	346.6	100	246.6	246.6

Table 4-42: Luminance Data on Second Floor for Block B

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD(MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik AHU	122.3	71.2	178.2	123.9	500	-376.1	-75.2
Bilik Pensyarah (6)	372.1	164.5	243.2	259.9	300	-40.1	-13.4
Bilik Profesor (6)	573	334.2	573.2	493.5	300	193.5	64.5
Bilik Profesor Madya (4)	337.2	328.7	328.1	331.3	300	31.3	10.4
Bilik Bincang 2	380.1	400.1	220.2	333.5	300	33.5	11.2
Tandas Lelaki	59	97	88	81.3	100	-18.7	-18.7

Tandas Perempuan	90.2	112.4	73.4	92.0	100	-8.0	-8.0
Koridor Tengah 1	201.3	132.3	237.9	190.5	100	90.5	90.5
Koridor Tengah 2	355.2	324.1	360.2	346.5	100	246.5	246.5

Table 4-43: Luminance Data on Second Floor for Block C

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD(MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Tangga	352.3	290.1	370.2	337.5	100	237.5	237.5
Bilik Riser	290.1	310.2	260.4	286.9	150	136.9	91.3
Bilik Telefon	270.1	320.3	280.9	290.4	500	-209.6	-41.9
Tandas Perempuan	180.4	114.7	113.2	136.1	100	36.1	36.1
Tandas Lelaki	62.3	93.2	82.4	79.3	100	-20.7	-20.7
Pantri	400.1	408.2	454.3	420.9	150	270.9	180.6
Bilik Fail (BEKM & BEKP)	640.2	440.3	300.2	460.2	150	310.2	206.8
Bilik Mesyuarat	230.2	600.1	280.7	370.3	300	70.3	23.4
Bilik Fail Subjek	550.3	617.2	492.3	553.3	150	403.3	268.8
Bilik Akreditasi	170.2	725.2	286.2	393.9	150	243.9	162.6
Comrack	330.2	175.3	292.3	265.9	100	165.9	165.9
Ruang Menunggu	177.4	166	180.6	174.7	100	74.7	74.7
Bilik Fail BEKC	628.2	445.1	197.2	423.5	150	273.5	182.3

All of the table shows the luminance data of third floor area of all block in Admin Building. Table 4-44 are shows that the corridor area have an excessive light so that it can be label as over lux level. The next three (3) area are accepted level and under lux level. Next, Table 4-45 shows most of the area are accepted level including corridor, toilet and lecturer rooms. While the three (3) area are under lux level. Furthermore, for Table 4-46, only one (1) rooms are label as under lux level while five (5) area including stair, corridor, Bilik Tuto 1 and Bilik Tuto 2 and also the toilet are over lux. For the corridor area, there have two window are not tinted yet. Therefore, an excessive daylight enter the area with lamp are still working. Finally, six (6) area are accepted level followed the standard.

Table 4-44: Luminance Data on Third Floor for Block A

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD(MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik AHU	128.2	75.3	169.3	124.3	500	-375.7	-75.1
Bilik Pensyarah (6)	327.9	432.6	370.2	376.9	300	76.9	25.6
Bilik Profesor (4)	234.2	250.2	280.6	255.0	300	-45.0	-15.0
Bilik Profesor Madya (6)	469.2	449.3	304.3	407.6	300	107.6	35.9
Tandas Lelaki	62	93	81	78.7	100	-21.3	-21.3
Tandas Perempuan	74	152	95	107.0	100	7.0	7.0
Koridor Tengah 1	1862.3	1603.2	1607.2	1690.9	100	1590.9	1590.9
Koridor Tengah 2	272.5	272.8	271.6	272.3	100	172.3	172.3
Ruang Tangga	203.4	310.2	360.2	291.3	100	191.3	191.3

Table 4-45: Luminance Data on Third Floor for Block B

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD (MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Bilik AHU	170.2	81.6	149.2	133.7	500	-366.3	-73.3
Bilik Pensyarah (6)	430.2	184.2	546.2	386.9	300	86.9	29.0
Bilik Profesor (6)	314.2	215.9	299.2	276.4	300	-23.6	-7.9
Bilik Profesor Madya (4)	398.2	450.1	310.2	386.2	300	86.2	28.7
Tandas Lelaki	176.2	86	190.4	150.9	100	50.9	50.9
Tandas Perempuan	112.2	93.2	221.3	142.2	100	42.2	42.2
Koridor Tengah 1	212.9	136.2	151.2	166.8	100	66.8	66.8

Koridor Tengah 2	145.2	210.2	179.6	178.3	100	78.3	78.3
Ruang Tangga	314.5	253.2	288.7	285.5	300	-14.5	-4.8

Table 4-46: Luminance Data on Third Floor for Block C

ROOM	LUMINANCE (LUX)			AVERAGE	MALAYSIA STANDARD(MS1525)	DEVIATION	TOLERANCE (±10%)
	FIRST	SECOND	THIRD				
Pusat Sumber	840.2	440.6	500.1	593.6	300	293.6	97.9
Bilik Riser	150.1	109.4	215.4	158.3	150	8.3	5.5
Bilik Telefon	104.3	120.7	100.6	108.5	500	-391.5	-78.3
Tandas Perempuan	140.4	240.2	180.3	187.0	100	87.0	87.0
Tandas Lelaki	143.7	280.3	250.4	224.8	100	124.8	124.8
Bilik Sembahyang	223.4	265	302.4	263.6	150	113.6	75.7
Bilik Tuto (L)	700	1000	900	866.7	300	566.7	188.9
Bilik Tuto (P)	650	765	638	684.3	300	384.3	128.1
Comrack	320.2	190.3	284.2	264.9	150	114.9	76.6
Bilik Profesor	587	585.7	584.6	585.8	300	285.8	95.3
Koridor	882.2	927.6	942.3	917.4	100	817.4	817.4
Tangga	345.6	291.4	343.5	326.8	100	226.8	226.8

4.5.3 Energy Saving Strategy for Lighting System

The lighting system in Admin Building of FKE consumed around 8% of the total energy consumption in Admin Building. The simultaneous use of lighting loads makes the lighting system one of the major consumer of electricity in the building [17]. The selected saving measures to be compared in energy saving for lighting are replacement from fluorescent lamp to LED, de-lamping and installing timer control. The specific energy saving measures for improvement and implementation plans can give significant impact in future.

(a) Installing Timer Control

One of simple way to boost energy efficiency within the building is to install timer control for lighting. It is a clock-based device that controls when the lighting is switched on and off. By controlling the setting light to turn off in desired time, the timer control can save energy. Furthermore, when one of consumer forget to switch off the lighting, it can lead to waste energy consumption of the building. In addition, a timer too can provide security for the building. Based on Globe Electrical Solution which are of company in Australia, timers can save up to 30% of lighting energy.

$$
\begin{aligned}
Monthly\ Energy\ Saving &= Total\ Lighting\ Energy\ \times 30\% \\
&= 18{,}489.24\ \times 30\% \\
&= 5{,}546.77\ kWh/month
\end{aligned}
$$

$$
\begin{aligned}
Monthly\ Cost\ Saving &= Energy\ Saving\ \times Tariff\ C1\ Rate \\
&= 5{,}546.77 \frac{kWh}{month} \times RM\ 0.365 \\
&= RM\ 2{,}024.57/month
\end{aligned}
$$

Admin Building consist of three block which is block A, block B and block C. This three important block are the uses lighting of every day. Some of area are operate lighting system 17 hours per day. So, the installation of timer control are compulsory needed to switch

ON and OFF by the accurate time. Cost for installation of each timer is RM89. It is Honeywell Digital Timer Programmable Switch HWTHC711A.

Table 4-47: Digital Time Switch

The product features are its available for 17 programmable ON and OFF settings for output control. It also allows for simple and reliable scheduling of electrical options. The consumer may program the time switch to automatically switch at a present time. The total number of timer control for installation are about 12 unit [38].

$$Total\ for\ installation = No\ of\ timer\ to\ install \times Cost\ for\ installation$$

$$= 12 \times RM89.00$$

$$= RM1068$$

$$Payback\ Period = \frac{Cost\ forInstallation}{Monthly\ Cost\ Saving}$$

$$= \frac{RM1{,}068}{RM2{,}024.57}$$

$$= 0.53\ months$$

(b) Delamping

One simple way to reduce energy are de-lamping. It is done by removing unnecessary light bulbs in criteria area that are producing greater-than-needed illumination. Thus, the lux level should measure and set a table to be compare with the lux measurement that follow Malaysia Standard (MS1525). From the result, the removing of the lamp are to be considered after analyse the over lux area. It is involve in the de-lamping section of this project. For the fluorescent lamps, the rated power are multiple with 1.8 since in the design of the discharge lighting for one complete circuit [32]. Table 4-48 show the saving of De-lamping information.

Table 4-48 The Saving of De-lamping Information

	Type of Lamps	Lamp's Feet	Rated Power (W)	Price Lamp (RM)	Total Removed Lamps (Unit)	Energy Saving (kWh/month)	Cost Saving (RM/month)	De-lamping cost (RM)
Level Ground	Fluorescent	2"	18	4	30	192.46	70.25	120
		4"	-	-	-	-	-	-
	LED	2"	10	10	46	91.08	33.24	460
Level 1	Fluorescent	2"	18	4	19	121.89	44.49	76
		4"	36	5	13	166.79	60.88	180
	LED	2"	10	10	42	83.16	30.35	420
Level 2	Fluorescent	2"	18	4	8	51.32	18.73	32
		4"	36	5	8	102.64	37.46	40
	LED	2"	10	10	32	63.36	23.13	320
Level 3	Fluorescent	2"	18	4	8	51.32	18.73	32
		4"	36	5	9	115.48	42.15	45
	LED	2"	10	10	32	63.36	23.13	320
TOTAL						1,102.86	402.54	2,045

(c) Change from Fluorescent Lamp to Light Emitting Diode (LED) Lamp

A lamp that emits light in a very narrow band of wavelength are known as light-emitting diode or LED for short. It is emit light in a much wider band of wavelength plus LED's are far more energy efficient than fluorescent lamp. In addition, LED's produce light that not identical to natural daylight. To show more efficient of LED's light are LED bulb may last around 25000 hours even though LED generally are more costly but the energy saved on electrical bills pays off when to fluorescent lamp [33].

Before this, Faculty of Electrical Engineering (FKE) has conduct Energy Efficiency Program and certain area of the Admin Building has been change to LED lamp such as ground floor block C and other corridor. To increase the energy efficiency in Admin Building, the replacement of all fluorescent lamp to LED lamp based on the lamp feet are one of the good proposed of energy saving strategy for lighting. The LED features really suitable for the energy saving measure of the Admin Building.

Based on the result, table shows that the information of replacement of fluorescent lamp to LED lamp. Table 4-49 and Table 4-50 are divide to lamp's two (2) feet, price of the LED lamp, total replacement, energy saving, cost saving and total of installation. While for Table 4-51 and Table 4-52, it show that result of energy saving, cost saving and total for installation for lamp's four (4) feet. The result to replace fluorescent lamp to the LED lamp shows that the cost of installation are higher but as we know LED has may last around more longer than fluorescent lamp.

Table 4-49: Data of Saving Changing Fluorescent Lamp Two Feet to LED Lamp

	Lamp's Feet	**Pricing Lamp per Tube (RM)**	**LED Lamp Rated Power (W)**	**Total Replacement (Units)**	**Energy Saving (kWh/month)**	**Cost Saving (RM/month)**	**Replacement LED Cost (RM)**
Level Ground	2"	10	10	110	217.80	79.50	1,100
Level 1	2"	10	10	84	166.32	60.71	840
Level 2	2"	10	10	135	267.30	97.56	1,350
Level 3	2"	10	10	61	120.78	44.08	610

Table 4-50: Total of Saving of Replacement Fluorescent Lamp Two Feet to LED Lamp

	Total Replacement (Units)	**Energy Saving (kWh/month)**	**Cost Saving (RM/month)**	**Replacement LED Cost (RM)**
Total	390	772.20	281.85	3900

Table 4-51: Data of Saving Changing Fluorescent Lamp Four Feet to LED Lamp

	Lamp's Feet	**Pricing Lamp per Tube (RM)**	**LED Lamp Rated Power (W)**	**Total Replacement (Units)**	**Energy Saving (kWh/month)**	**Cost Saving (RM/month)**	**Replacement LED Cost (RM)**
Level Ground	4"	13	18	266	948.02	346.03	3,458
Level 1	4"	13	18	381	1,357.88	495.63	4,953
Level 2	4"	13	18	293	1,044.25	381.15	3,809
Level 3	4"	13	18	270	962.28	351.23	3,510

Table 4-52: Total of Saving of Replacement Fluorescent Lamp Two Feet to LED Lamp

	Total Replacement (Units)	**Energy Saving (kWh/month)**	**Cost Saving (RM/month)**	**Replacement LED Cost (RM)**
Total	1210	4,312.43	1,574.04	1,5730

$$Payback\ Period = \frac{Cost\ for\ Replacement\ LED\ Lamp}{Monthly\ Cost\ Saving}$$

$$= \frac{RM\ 3900 + RM15730}{RM281.85 + RM1574.04}$$

$$= 10.6\ Months$$

(d) Installation of Motion Sensor Control

There is one way to save a significant amount of energy which is light controls that reduce or turn off the lighting when the space is not in use. Pacific Northwest National Laboratory [34] study that an adding lighting controls can reduce lighting energy use 10% to 90% or more depending on the use of the space in which sensor are installed. One study conducted on a university campus found that by installing wired occupancy sensor in more than 200 rooms provided an annual cost saving about $14,000 with a simple payback of 4.2 years [35].

Occupancy sensor are type of lighting control that automatically turns on the lights when someone are enters the space and switch off the lights after a user leave the room after the sensor detect no movement. Occupancy sensor work well with all type of room and more efficiency with the room do not have window or other source that provide daylight. One of the best time delay setting are the less time it stays on, the higher the savings will be. One study shows that by installing motion sensor controlled lighting at office building savings 24% with a 10 minutes delay [36].

Therefore, installation of motion sensor control light are one of the strategy for energy saving measure. The motion sensor control light should be installed to all lecture room, fail room, meeting room, stored room and all room that have a private space with the locked door. Admin Building consist of 127 lecturer room and 37 other private room.

Figure 4-21: Morris 80540 Wall Mount Occupancy/Vacancy Sensor, PIR Double Pole, and 3Way

$$Monthly\ Energy\ Saving = Total\ Lighting\ Energy\ \times 24\%$$
$$= 17020.08\ \times 24\%$$
$$= 4{,}084.82\ kWh/month$$

$$Monthly\ Cost\ Saving = Energy\ Saving\ \times Tariff\ C1\ Rate$$
$$= 4{,}084.82 \frac{kWh}{month} \times RM\ 0.365$$
$$= RM\ 1{,}490.96\ /month$$

$$Total\ for\ installation\ = No\ of\ timer\ to\ install\ \times Cost\ for\ installation$$
$$= 164 \times 81.90$$
$$= RM\ 13{,}431.60$$

$$Payback\ Period = \frac{Cost\ forInstallation}{Monthly\ Cost\ Saving}$$
$$= \frac{RM 13{,}431.60}{RM 1{,}490.96}$$
$$= 10\ months$$

4.5.4 Monthly Lighting System Energy and Cost Consumption

Each of the strategies that have been proposed to reduce energy consumption and cost consumption in Admin Block. Every each strategies give a different rate of percentage reduction. From figure and shows timer controller have 30 % reduction, de-lamping have only 6% reduction, replacement fluorescent to LED save 28% and motion sensor control only save

24% of saving. Therefore the total energy saving and cost saving are 15,819.05 kWh/month and RM 5,784.90 /month.

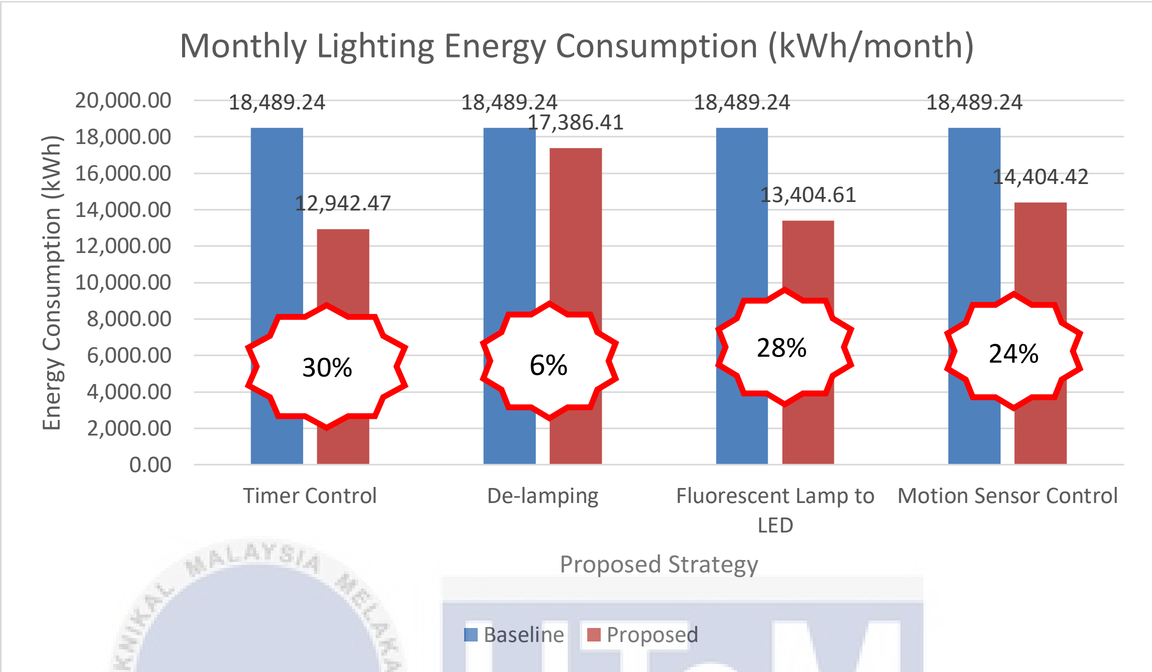

Figure 4-22: Monthly Lighting System Energy Consumption

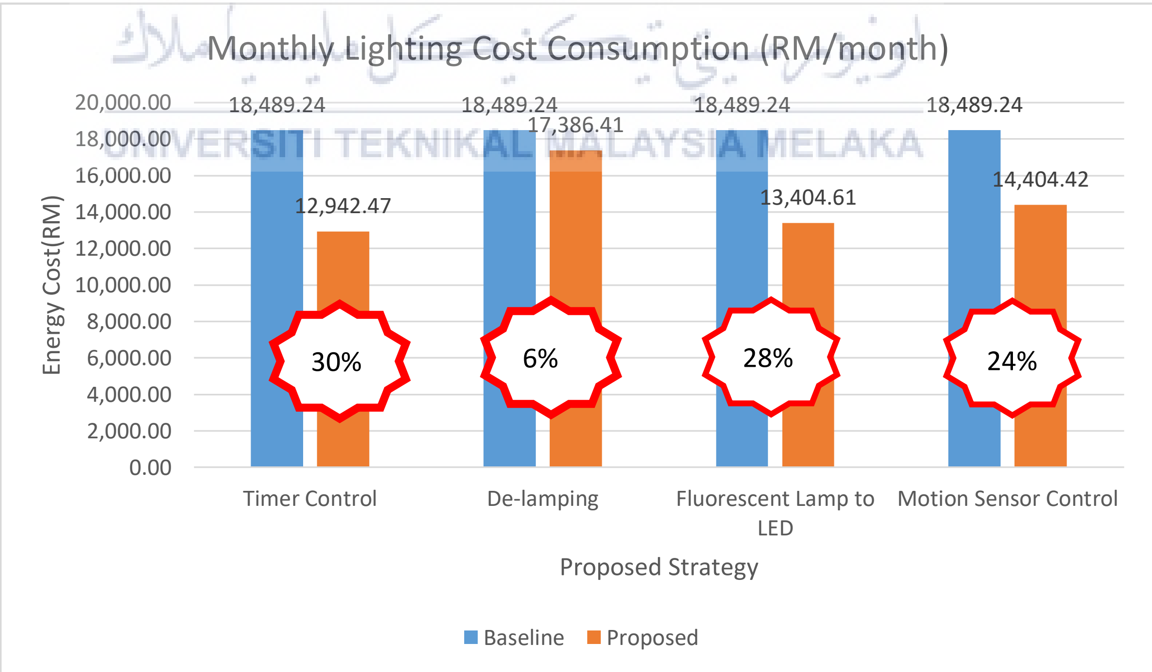

Figure 4-23: Monthly Lighting System Cost Consumption

4.6 Electrical Equipment

4.6.1 Electrical Equipment Data

Electrical device such as office equipment commonly used electrical appliances are generally controlled by consumer. These loads are normally turned on by occupants but are often left on longer than necessary [37]. Admin block consist of many rooms, lecturer, staff and student. The operation hour continuously operation in 9 hours straight because admin block are the main area than other block of FKE. Table shows the electrical equipment of ground floor area. From the data, most of the lecturer room consist of same equipment such as CPU, monitor, voltage regulator and battery charger. While Bilik Kuliah (BK) consists of projector, monitor, CPU and fan. The brand of the devices also have to be consider to analyze the data of power consumption. Next, Table 4-54 show the result of data electrical device at the first floor. The first floor are where the administration staff work. Therefore, the number of consumer that use the electrical device are also increase. So that, the energy consumption of electrical device are the highest than other floor. Moreover, Table 4-55 are the information data of electrical devices on second floor. Generally, the second floor equipment have the similar information with the ground floor except there is not so many number of lecture room and the energy consumption are lower than the ground floor. Finally, Table 4-56 shows the information of electrical device on the third floor. The third floor has the least information of data than other floor since there is not a lot of rooms and people that use the third floor.

Table 4-53 Information of Electrical Equipment at Ground Floor

Room	Other tools	Power (W)	No. of tools	Time of use (Hours)	Total of Power (W)	Energy Consumption (kWh)
Bilik Pensyarah (30)	CPU (Intell)	84	1	9	2520	22.68
	Monitor (Dell)	30	1	9	900	8.10
	AC Adapter	65	1	9	1950	17.55
	Phone Charger	5	1	9	150	1.35
	Voltage Regulator	800	1	9	24000	216.00
Bilik Kuliah (2)	Monitor (Dell)	30	1	9	60	0.54
	CPU (Intell)	84	1	9	168	1.51
	Projector	300	1	9	600	5.40
	Voltage Regulator	800	1	9	1600	14.40
	Fan	70	3	9	420	3.78
Unit Akademik	Monitor (Dell)	30	3	9	30	0.27
	CPU (Intell)	84	3	9	84	0.76
	Photostat machine	700	1	9	700	6.30
Ruang Lobi	Coway	672	1	9	672	6.05
Total						**304.69**

Table 4-54 Information of Electrical Equipment at First Floor

Room	Other tools	Power (W)	No. of tools	Time of use (Hours)	Total of Power (W)	Energy Consumption (kWh)
Bilik Pensyarah (32)	CPU (Intell)	84	1	9	2680	24.12
	Monitor (Dell)	30	1	9	960	8.64
	AC Adapter	65	1	9	2080	18.72
	Phone Charger	5	1	9	160	1.44
	Voltage Regulator	800	1	9	25600	230.40
Bilik Seminar (1)	Monitor (Dell)	30	1	9	30	0.27
	CPU (Intell)	84	1	9	84	0.76
	Projector	300	1	9	300	2.70
	Voltage Regulator	800	1	9	800	7.20
Bilik KPP (1)	CPU (Intell)	84	1	9	84	0.76
	Monitor (Dell)	30	1	9	30	0.27
	AC Adapter	65	1	9	65	0.59
	Phone Charger	5	1	9	5	0.05
Bilik Ketua Jabatan (4)	CPU (Intell)	84	1	9	336	3.02
	Monitor (Dell)	30	1	9	120	1.08
	AC Adapter	65	1	9	260	2.34
	Phone Charger	5	1	9	20	0.18
Bilik Timbalan Dekan (2)	CPU (Intell)	84	1	9	168	1.51
	Monitor (Dell)	30	1	9	60	0.54
	AC Adapter	65	1	9	130	1.17
	Phone Charger	5	1	9	10	0.09

Bilik Dekan (1)	CPU (Intell)	84	1	9	84	0.76
	Monitor (Dell)	30	1	9	30	0.27
	AC Adapter	65	1	9	65	0.59
	Phone Charger	5	1	9	5	0.05
Pejabat Pentadbiran	CPU (Intell)	84	5	9	84	0.76
	Monitor (Dell)	30	5	9	30	0.27
	Fan	70	1	9	70	0.63
	Photostate Machine	700	1	9	700	6.30
	Coway	672	1	9	672	6.05
Bilik Bincang	CPU (Intell)	84	1	9	84	0.76
	Monitor (Dell)	30	1	9	30	0.27
Total						**322.55**

Table 4-55: Information of Electrical Equipment at Second Floor

Room	Other tools	Power (W)	No. of tools	Time of use (Hours)	Total of Power (W)	Energy Consumption (kWh)
Bilik Pensyarah (32)	CPU (Intell)	84	1	9	2680	24.12
	Monitor (Dell)	30	1	9	960	8.64
	AC Adapter	65	1	9	2080	18.72
	Phone Charger	5	1	9	160	1.44
	Voltage Regulator	800	1	9	25600	230.40
Bilik Seminar (1)	Monitor (Dell)	30	1	9	30	0.27
	CPU (Intell)	84	1	9	84	0.76

	Projector	300	1	9	300	2.70
	Voltage Regulator	800	1	9	800	7.20
Koridor Tengah	Coway	672	1	9	672	6.05
	Photostate machine	700	1	9	700	6.30
Bilik Mesyuarat	CPU (Intell)	84	1	9	84	0.76
	Monitor (Dell)	30	1	9	30	0.27
	Projector	300	1	9	300	2.70
Bilik Bincang	Monitor (Dell)	30	1	9	30	0.27
	CPU (Intell)	84	1	9	84	0.76
Total						**311.35**

Table 4-56 Information of Electrical Equipment at Third Floor

Room	Other Tools	Power (W)	No. of tools	Time of use (Hours)	Total of Power (W)	Energy Consumption (kWh)
Bilik Pensyarah (30)	CPU (Intell)	84	1	9	2520	22.68
	Monitor (Dell)	30	1	9	900	8.10
	AC Adapter	65	1	9	1950	17.55
	Phone Charger	5	1	9	150	1.35
	Voltage Regulator	800	1	9	24000	216.00
Koridor Tengah	Photostate Machine	700	1	9	700	6.30
Total						**271.98**

4.6.2 Summary of Electrical Device Energy and Cost Consumption

Table 4-57 shows the final result of data of energy consumption and cost consumption by month. First floor has the highest energy consumption of electrical device since this floor are consist of administration area, lecturer rooms and also lecture rooms. The lowest energy consumption are followed by third floor since there is only consist of lecturer room but not all of the room are fill in with the lecturer. With this information, the energy saving are planning based on how to reduce the energy consumption of electrical device with under control from people.

Table 4-57: Summary of Electrical Device Energy Consumption

Building	Floor	Energy Consumption (kWh)	Energy Consumption per month (kWh/month)	Cost (RM/month)
Block A, Block B, Block C	Ground Floor	304.69	6,703.18	2,446.66
	First Floor	322.55	7,096.10	2,590.08
	Second Floor	311.35	6,849.70	2,500.14
	Third Floor	271.98	5,983.56	2,184.00
	Total	**1,210.57**	**26,632.54**	**9,720.88**

4.6.3 Energy Saving Strategy for Electrical Devices

The sustainable way to improve the electrical equipment energy management system are by applying the awareness and motivation. Since the electrical and electronic equipment data could not be controlled the power consumption such as lighting and air-conditioning. Therefore, there are several planning to improve the awareness and motivation among the staff, lecturer and students. The energy saving of this planning does not have accurate percent of saving. So that, the best no-cost measure that can be taken are prove in table below. Based on energy saving strategies in the FKE, UTM, the annual energy consumption can reduce to 10.9% with the energy efficiency awareness campaign that were held on 2011 [4].

Table 4-58: Awareness and Motivation Planning

Activity	Description	Energy Saving	Achievement
Switch off program	Switch off all computers, printers and associated equipment when leaving.	2%	The heat given by equipment may add to higher usage of air conditioning and also energy consumption.
Use efficient appliance	Use equipment that label with 4 or 5 star rating by Suruhanjaya Tenaga (ST)	2%	Help to save energy consumption.
Energy Efficiency Sharing Session	Reporting current Energy Management status and energy tips during meeting	2%	Create awareness and energy management program transparent to all staff
Energy Saving Tips Poster	Design creative and interactive poster and also publish at strategic area.	2%	Promote energy efficiency program toward greener lifestyle.

4.7 Overall Energy Saving Strategies

The data collection and measurement of admin block consist of energy consumption of lighting, air-conditioning and also electrical equipment or office equipment. The energy saving focus more to the highest energy usage and the data can be controlled such as air-conditioning and lighting. For electrical equipment, the data of equipment are uncontrolled because the equipment totally depend on consumer. Therefore, the energy saving strategies for electrical equipment are more to awareness, training and motivation. Next, the energy saving that have been proposed are to reduce the energy consumption and cost consumption in every month for

1 year. Every energy saving strategy have given different rate of reduction in term of energy and cost consumption. The total energy saving are about 1,170,769.08 kWh/year with cost saving RM 427,330.71 /year. In a month, the energy consumption can save up to 97,564.09 kWh/month. Therefore, the percentage of saving 43.79% for energy consumption and also energy efficiency index (EEI).

4.7.1 Energy Efficiency Strategies

$$\text{Monthly Energy Saving of Lighting (kWh/month)}$$
$$= 5{,}546.77 + 1{,}102.83 + 5084.63 + 4084.82$$
$$= 15{,}819.05$$

$$\text{Monthly Energy Saving of Air} - \text{Conditioning (kWh/month)}$$
$$= 41{,}054.26 + 13{,}585.66 + 3357.00 + 23{,}748.12$$
$$= 81{,}745.04$$

$$Total\ Monthly\ Energy\ Saving(kWh/month) = 15{,}819.05 + 81{,}745.04$$
$$= 97{,}564.09$$

$$Energy\ Saving\ \ (kWh/year) = 97{,}564.09 \times 12$$
$$= 1{,}170{,}769.08$$

$$Cost\ Saving\ (kWh/year) = Energy\ Saving\ \times Tariff\ C1\ Rate$$
$$= 1{,}170{,}769.08 \times \text{RM } 0.365$$
$$= \text{RM } 427{,}330.71$$

$$Installation\ Cost\ of\ Lighting = RM\ 1{,}068 + RM\ 2{,}045 + RM\ 19{,}630$$
$$= RM\ 22{,}743$$

$$Installation\ Cost\ of\ Air - Conditioning = RM\ 23{,}280$$

$$Total\ Installation\ Cost = RM\ 22{,}743 + RM\ 23{,}280 = RM\ 46{,}014$$

$$Payback\ Period = \frac{RM\ 46{,}014/year}{RM\ 427{,}330.71\ kWh/year}$$

$$= 0.11\ years \approx 2\ months$$

4.7.2 Energy Efficiency Index (EEI) After Energy Saving

$$EEI = \frac{Total\ energy\ used\ (kWh/year)}{Gross\ Floor\ Area\ (m^2)}$$

$$EEI = \frac{1{,}502{,}641.14}{5{,}387.89}$$

$$= 278.89\ kWh/m^2/year$$

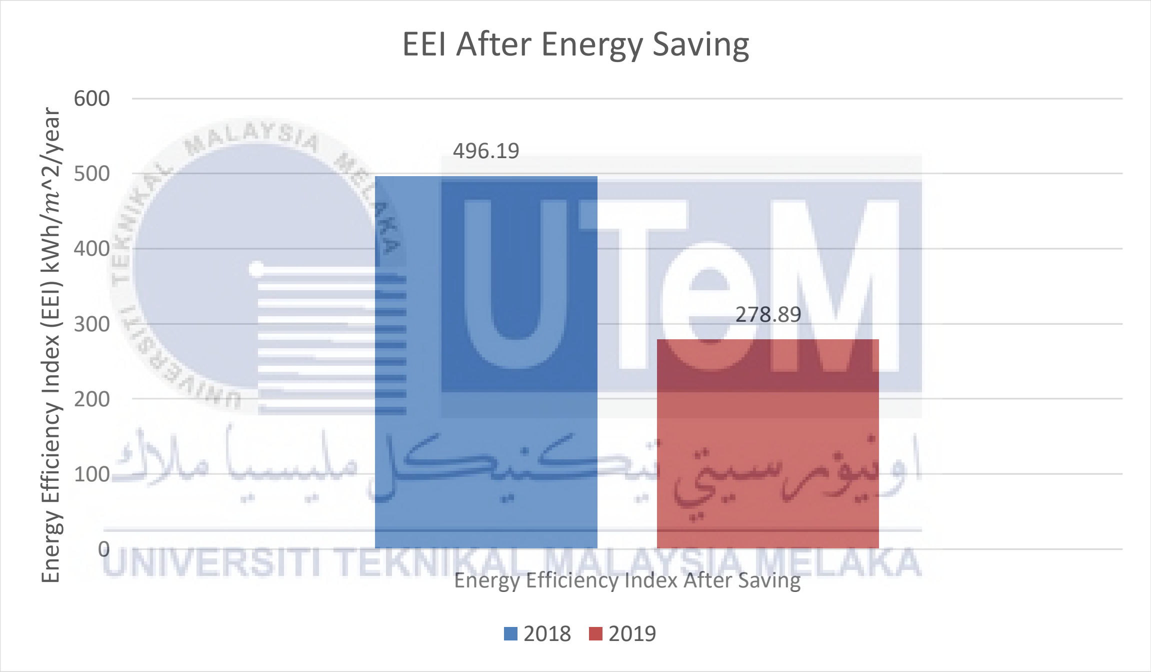

Figure 4-24: Energy Efficiency Index (EEI) after Energy Saving

From Figure 4-24 shows the energy efficiency index (EEI) after proposed energy saving measured for each load consumption which is lighting, air-conditioning and office equipment. From the result, there is difference of EEI before and after proposed energy saving. The difference between EEI are 217.30 kWh/m^2/year which is the rate of reduction are 43.79%. The new EEI are still not acceptable with the Malaysia Standard MS 1525:2007 for office building which is the benchmark maximum are 220 kWh/m^2//year. The difference between new EEI and standard office EEI are 58.89 kWh/m^2//year, therefore there is still need more proposed energy saving and data measurement to achieve the standard EEI for office building. With the flexible and more time, the new EEI will be meet standard requirement which is below 222 kwh/m^2//year in the future.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section basically overview the conclusion in the work that have been done in Projek Sarjana Muda 1 (PSM 1) and work progressing in Projek Sarjana Muda 2 (PSM 2).

5.2 Conclusion

In conclusion, the objective of this project are achieved. From previous audit, data of lighting, air-conditioning and electrical equipment for energy consumption data have been collect through work survey and Pejabat Pembangunan, UTeM. The measurement of lux and temperature are using an equipment that borrowed from Energy Efficiency Laboratory. By measuring the energy performance of air-conditioning, it shows the peak hour of air conditioning performance for one day. All of data collection are to determine which area should proposed energy saving.

Next, lighting and air-conditioning for energy saving are focus more to technical saving. It is because of the data that collect previously can be controlled and vary to reduce the energy consumption. For electrical equipment, most of data could not be controlled the consumption because the equipment that consumer bring in and out of Admin Block could never track the consumption. Therefore, the electrical equipment more focus to awareness training to reduce the energy consumption.

For lighting system, the existing equipment may not existing as the most efficient equipment but it consume 8% from the total load. Therefore, it is fair to give a small focus to lighting for the energy saving measures after air-conditioning. The proposed saving for lighting such as install time controller, change fluoresecent light to LED lamp, delamping and install motion sensor. All of the saving give more than 20% energy saving from the total load.

For air-conditioning, it is a major load that consume high energy consumption which is 71% from the total load. Therefore, the saving more focus to the maintenance and timing of air-conditioning consume. The proposed energy saving more to reduce air-conditioning temperature, cleaning air filter of AHU, install split unit at more useful area and audit operating time of AHU. Its does not have high cost installation and the payback period are more shorter. This energy saving can be verified an efficient saving because it is not only saving cost and energy consumption but also the cost installation and payback period are also reduce.

Although, the energy efficiency index of Admin Block are still not below than Malaysia Standard which is office building energy efficiency index below than 220 kWh/m^2/year. But rate of the energy saving are higher than 20% from the total saving. Overall,total of EEI can be identified and improved.

5.3 Future Recommendation

To make this project become more successful and become better with high quality, there are some of recommendations that will be stated.

First, most of FKE laboratory does not have enough equipment. For the future, FKE should buy more measurement equipment such as power logger. This is because lack of equipment can lead to limit of time to gather all of the necesary information. When all of the equipment enough, the measurement of data can be analysis and collect more detailed for each floor of Admin Block.

Next, after the proposed of energy saving, it is highly recommended to monitor and control the energy consumption. From the monitoring, we can accurately know the energy saving and maintain the saving to achieve 3-Star EMGS in future.

Moreover, to get an accurate data of lighting, air conditioning and electrical equipment, the measurement must take from meter equipment. TNB does not provide any meter equipment which is an equipment that can read data of each load. So an actual data cannot be achieved.

Finally, the monthly bill of Admin Building cannot provided because TNB only measure the monthly bill for all of building of UTeM. Therefore, we should suggest to UTeM to split the bill based on building so that we could determine the actual consumption more accurate.

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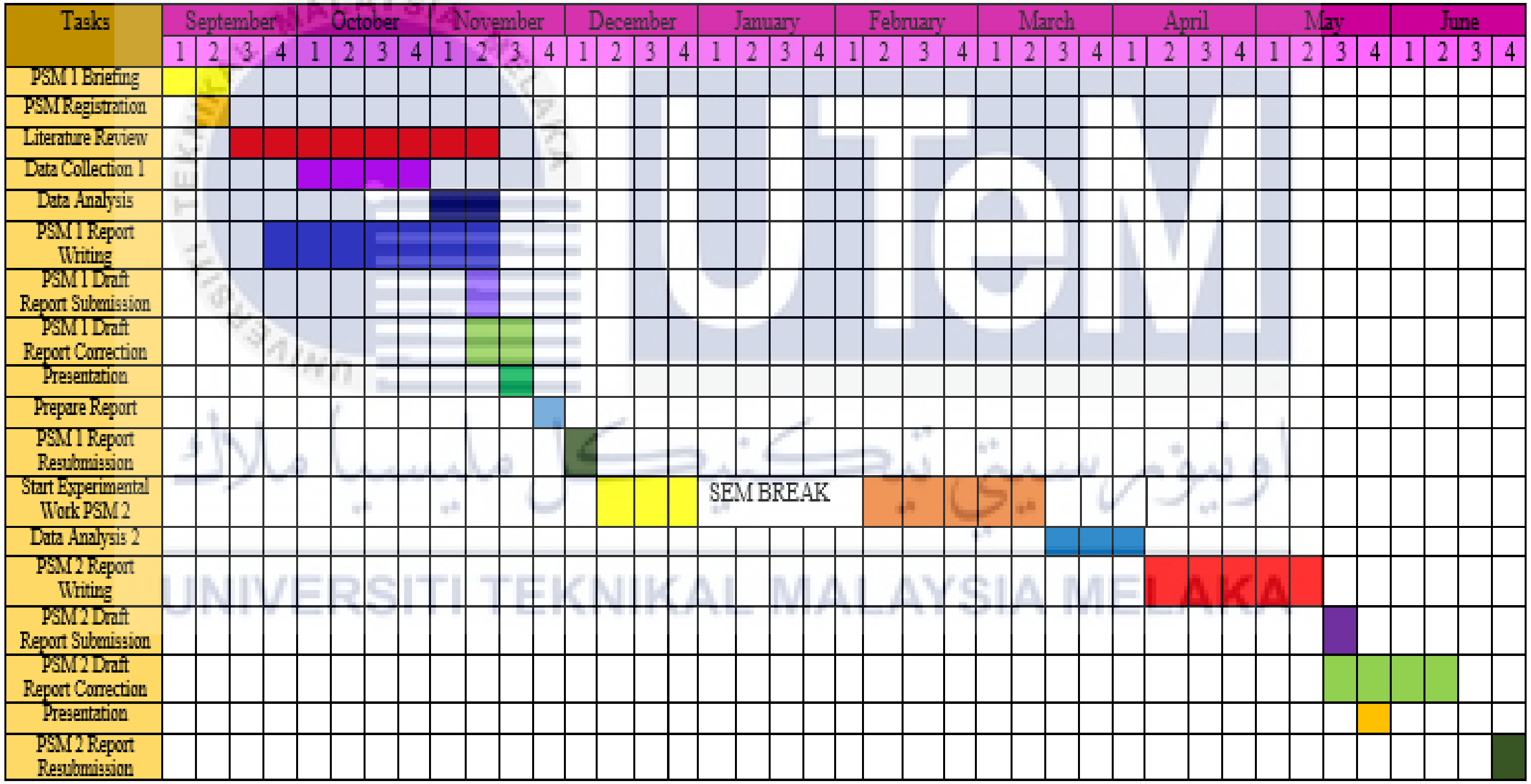
APPENDICES

APPENDIX A GANTT CHART



APPENDIX B UTeM ENERGY POLICY 2015

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UTeM ENERGY POLICY

Declaration of Commitment

Universiti Teknikal Malaysia Melaka (UTeM) is committed:

1. To continually improve the energy efficiency and conservation throughout its campus in carrying out its teaching and learning, research, and service operation through the implementation of effective energy efficient management.
2. To address and act towards processes and activities that will give impact on the performance of electrical energy usage at all premises within UTeM.
3. To ensure compliance towards the act and regulations on efficient management of electrical energy.

Professor Datuk Dr. Shahrin bin Sahib
Vice Chancellor
Universiti Teknikal Malaysia Melaka

Pusat Kelestarian dan Alam Sekitar (PKA)/*Centre for Sustainability and Environment(CSE)*