Energy Audit in Block 3 in S&T Tower towards Energy Efficiency in UiTM Shah Alam

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Abstract— **This paper presents a study of baseline zero energy wastages for various buildings in Universiti Teknologi Mara (UiTM), Shah Alam. The main purpose of this study is to reduce energy consumption and achieve zero energy wastages for Block 3 Science and Technology Tower (S&T Tower) in UiTM Shah Alam. It can be achieved by conducting an energy audit to the Block 3 S&T Tower in UiTM Shah Alam. The purpose of the energy audit is to identify the pattern of the load profile. An energy audit is also considered as one of the comprehensive ways or methods in checking the energy consumption and wastage in buildings. By improving energy efficiency, it can reduce energy consumption and lead to reduce the utility bill. Fluke Meter 1750 was installed on Distribution Board to collect data for Block 3 in S&T Tower. Based on the data obtained, strategic steps can be recommended to reduce the total energy consumption.**

Keywords-energy consumption; energy wastages; energy audit; energy efficiency; load profile

I. INTRODUCTION

Energy management is a structured approach designed to manage energy usage and minimize energy costs without affecting production and quality. [1] In other word, energy management is to produce goods and provide services with the least cost. The energy management practice has traditionally focused exclusively on technologies that increase the energy efficiency. [2] Energy efficiency means using less energy to provide the same level of performance or service. Efficient energy use is achieved by using more efficient technologies or processes rather than by changing human behavior. [3]

An energy audit can be conducted to determine how efficient the energy is used. An energy audit is a systematic review of energy sources and utilizations of an energy user such as building to determine its energy performance and identify energy conservation measures for improvement. [4] It is also an activity in the implementation of energy management that assists energy end users to identify ways to achieve energy performance target. [5] By conducting the energy audit, the wastage energy can be identified. Energy wastage can lead directly to the increase of cost.

In Malaysia, the government is fully committed in an effort to ensure that energy is utilized efficiently. According to Kementerian Tenaga Teknologi Hijau dan Air (KETTHA), by setting the used of air-conditioning into 24 degrees Celsius, it will help to reduce energy bills. If the degrees drop by one degree to 23 degrees Celsius, it means the expenditure has increased from 4 to 7 per cent. By applying this, it had helped reduce the energy bill up to RM 700, 000 a year. From the result, it shows the energy efficiency is important in order to reduce power and save energy. Therefore, it is good to implement energy efficiency to UiTM buildings. Air-conditioning is a major contributor to energy consumption in UiTM Shah Alam. [6]

Nowdays, UiTM Shah Alam faced a problem with energy wastage that caused increasing in electric bills. UiTM Shah Alam has spent almost RM 24.6 million on electricity bill for the year 2011. This means, the average spending for electrical bill per month was RM 2.05 million for the year 2011. For half year of 2012 which is in between January 2012 until June 2012, UiTM Shah Alam has spent a total of RM 13.7 million for electrical bill. Average spending for electrical bill per month for half year of 2012 has increased compared to the year 2011 which is RM 2.28 million per month. One of the important factors that relate to an increase of the electric bill was energy efficiency. [7] Building in UiTM Shah Alam consists of Library, offices, hostels for students, stadium, faculty and many more. Our scope of research only focus in Block 3, S&T Tower in order to know the energy pattern consumption, load pattern and how to reduce energy wastage at the building. Block 3 covers 9 levels which are from level 3 to level 12.

The objectives of this project are:

i. To identify the pattern of the load profile at Block 3 S&T Tower.
ii. To study the energy wastage for Block 3 S&T Tower in UiTM Shah Alam
iii. To analyze energy consumption for the buildings and identify the buildings that has been using energy exceeds the limit.
iv. To give recommendations for reduce energy wastage.

By studying the use of energy wastage for building in UiTM Shah Alam, it can identify the pattern of load profile. The load that causes overload percentage energy used can be detected. Besides, this research will help for technician or person in charge the building in UiTM Shah Alam how to reduce the energy wastage. Strategic steps or educational steps can be suggested so as to reduce the wastage of power.

II. METHODOLOGY

Before start the energy audit, a review about Malaysian standard must be done. The Malaysian Standard MS 1525:2007 provides the criteria and minimum standards for energy efficiency in the design buildings, retrofit of existing buildings and method for determining compliance with these criteria and minimum standard.

Figure 1 shows a flow chart of work progress while completing this project. It has involved of walk through survey, data collection and analyzing data. Energy survey or energy audit used to record all electrical appliances used in the building. It consists of lighting, air-conditioning, computer, fan and others. By using theoretical calculation, the power consumption can be estimated.

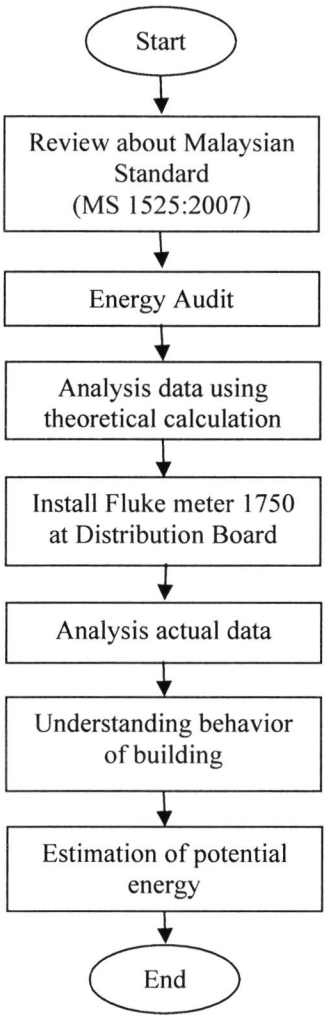

Figure 1: Flowchart of work progress

A. Identify area of energy audit

The energy audit process begins from the preliminary audit which has to identify energy efficiency of the lighting system, air-conditional system and loads for Block 3 S&T Tower in UiTM Shah Alam.

B. Preliminary audit / walk in audit

The preliminary audit is the source of information for the success in the energy audit program. Walk in audit have been done in Block 3. It is more to the time-consuming data gathering and some information about the audit. It is divided into several elements which are utility bills, lighting system and air-conditioning system. Utility bills provide the information of the energy consumption in the S&T Tower. It will be a historical record for a growth of the energy consumption in the S&T Tower. So, a trend of energy consumption can be observed. Lighting also makes a major impact on energy consumption in Block 3. The efficiency of lighting system can be made through the survey. Air-conditioning is a major impact on energy consumption. Data on air-conditioning should include the capacity of the system, the condition of the equipment and the operating schedule of the equipment.

From the audit, Block 3 consists of 9 levels which are from level 3 to level 12. Block 3 consists of classrooms, offices, toilets, labs, computer labs, corridors, meeting rooms, engineering lab, technician's rooms and many more. The quality of computers in Block 3 is quite high because there are 8 computer labs. Each level consists of two toilets. Every lab has at least 2 technician's rooms.

Table 1 below shows the types and the quality that consists in Block 3. There are 1365 units of lamp consist of fluorescent lamps (1x36W, 2x36W, 1x18W, 2x18W), Downlight (1x18W, 2x18W) and halogen (50W). The average operating hour for lighting is 12 hours per day. Some of the lighting operates 24 hours per day such as the corridor lightings. Each level have an average number of lighting which is up to 26 units of 36W light (13 units 2x36W). Water cooler operating time is also 24 hours per day. For the fans, most of them are placed in the classroom.

Table 1: Total Energy Consumption in Block 3

Types	**Quality (unit)**
Lighting	1365
Computer	246
Socket	799
Water Cooler	6
Fan	33
Projector	31
Fridge	1
Television	1

C. *Installation*

Fluke meter 1750 was installed on Distribution Board (DB) in the Block 3 S&T Tower to get the actual data of energy consumption. This meter has been set for 10 to 15 minutes for a week in the place.

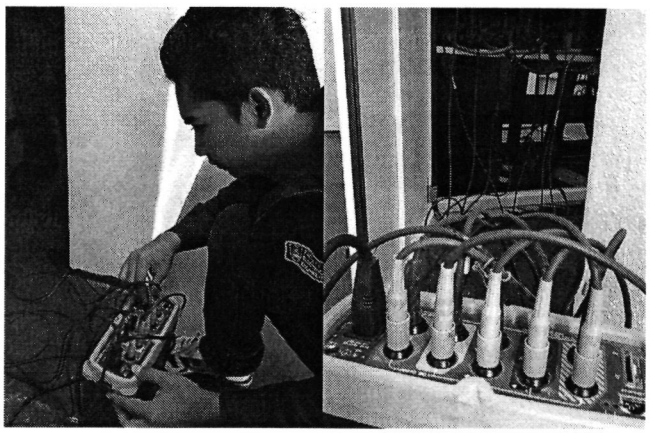

Figure 2: Installation using Fluke meter 1750

III. RESULT AND DISCUSSION

A. *Load Factor*

Load factor can be defined as the average load divided by the peak load in a specified time of period. The value of the load factor is always less than one. It is because maximum demand is always more than average demand since we will not connect all the loads at a time. A high value of load factor means power usage is relatively constant while low load factor shows that an occasionally a high demand is set. Below shows the formula to calculate Load Factor:

$$f_{load} = \frac{Total\ Energy\ used\ (kWh)}{Maximum\ Load\ in\ given\ time\ period}$$

This project has been done in two conditions, which are during holiday and normal operating month. Two load factors are calculated. Below shows the value of Load Factor during the normal operating month calculated from 1st December 2012 until 31st December 2012. The value of Load Factor during the normal operating month is 0.4956. The maximum demand during the normal operating month is 320.67334 kW on 5th December 2012 at 3:45 pm. Total energy consumption in December 2012 is 118323 kWh.

$$f_{load} = \frac{(7244753 - 7126521)\ kWh}{(320.67334\ kW) x\ (24h) x\ (31\ days)} = 0.4956$$

Below shows the value of Load Factor during the holiday calculated from 1st January 2013 until 31st January 2013. From the result obtained below, the value of the Load Factor during the holiday is 0.4951. The maximum demand for the holiday is 281.843903 kW on 8th January 2013 at 11:30 am. Total energy consumption in January 2013 is 103813 kWh.

$$f_{load} = \frac{(7348566 - 7244753)\ kWh}{(281.843903\ kW) x\ (24h) x\ (31\ days)} = 0.4951$$

From the result obtained, the value of Load Factor during holiday and normal operation month is not much different. The value of Load Factor during the normal operating month is little bit higher than the holiday.

B. *Total Energy Consumption*

Energy audit was conducted in Block 3 S&T Tower. By doing an evaluation and analysis of the audit, energy consumption at Block 3 can be calculated. It can be categorized into several groups which are lighting, air-conditioning, computer, water cooler, fan and others. Others include projector, printer, television and freezer.

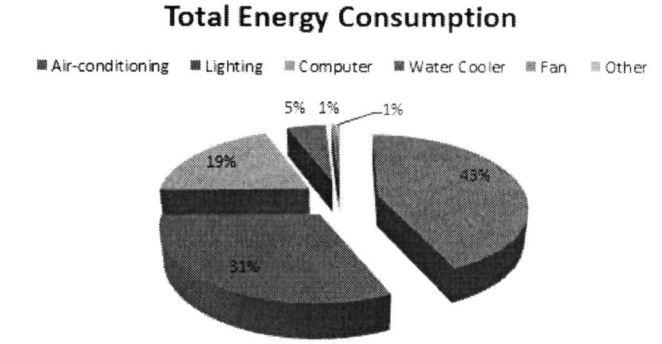

Figure 3: Total Energy Consumption in Block 3

Figure 3 shows the energy consumption at Block 3 S&T Tower based on the group mentioned before. From the figure, air-conditioning consumed highest energy usage which is 43% followed by lighting 31%, computer 19%, water cooler 5%, fan 1% and others 1%.

Percentage of energy consumed for each group can be calculated by using formula below:

$$\text{Percentage (\%)} = \frac{Energy\ Consumption\ (kWh)}{Total\ of\ Energy\ Consumption\ (kWh)}$$

Table 2: Total Energy Consumption in Block 3

Types	Energy (kWh/day)	Percentage (%)
Air-conditioning	1402.48	43
Lighting	1019.50	31
Computer	629.76	19
Water Cooler	161.28	5
Fan	15.84	1
Other	15.70	1
Total Energy	3244.56	100

Theoretically, air-conditioning used more energy than other electric equipment due to the Second Law of Thermodynamic. [8] Based on the data in Table 1, it proved that air-conditioning is the highest energy usage. The average operating hour for air-conditioning is 9 hours per day. Air-

conditioning contributed 43% of the total energy. There are two types of air-conditioning in Block 3. The 1st type of air-conditioning is centralized controlled by the chiller. It was set to automatically turn on and off. For example,most of the classrooms were controlled by this type of air-conditioning. The whole S&T Tower that consists of Block 1, Block 2, Block 3, Block 4, Block 5, Tower 1 and Tower 2. This bill was separated with the Block 3 and the tariff used is C3. The 2nd type of air-conditioning is split unit. This type of air-conditioning can be controlled manually. This type of air conditioning was placed at the offices and other places. The tariff used is C2. 43% used of energy consumption comes from air-conditioning type split unit.

Lighting is the second major energy usage at Block 3. This is due to the large number of lighting being used in that block. There are 1365 units of lamp consist of fluorescent lamps (1x36W, 2x36W, 1x18W, 2x18W), Downlight (1x18W, 2x18W) and halogen (50W). The average operating hour for lighting is 12 hours per day. For corridor lighting, its operating hour is 24 hours per day.

Computer contributes the third major energy usage in Block 3. Block 3 has 8 Lab Computers with a total 246 units computer. For the other equipment such as water cooler, fan, television, printer, projector and freezer only contribute 1% of the total energy.

C. *Average Energy Consumption on weekday and weekend*

Fluke meter 1750 was installed and located in the Main Switch Board (MSB) in the Block 3 S&T Tower substation. The meter setting was set for 15 minutes and being placed for a month. It is necessary to identify the loads pattern of the energy usage on working days and weekends. The result shows the different behavior between both conditions.

Part 1: Holiday (January 2013)

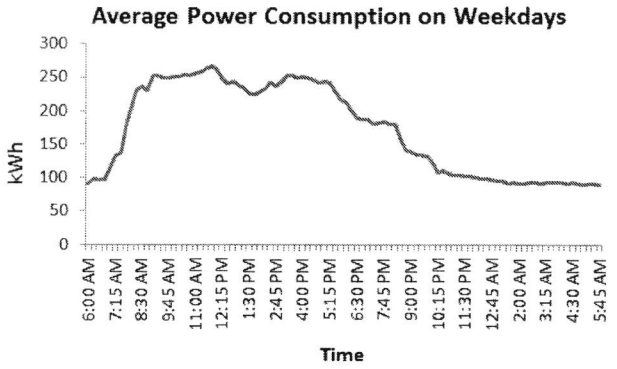

Figure 4: Average Power Consumption on Weekdays (January 2013)

Figure 4 shows the average power consumption on Weekdays at Block 3 S&T Tower during the holiday. There is no classes operate during holiday except offices. The maximum average power consumption on weekdays is 260 kWh. From the graph, the power consumption starts increasing at 7.15 am. At this time, most of electrical appliances start to operate. At 12.00 pm until 2.00 pm, the power consumption decreasing a little bit due to the lunch hour. After 5.00 pm, the power consumption begins to decrease. In Malaysia, 8.00 am to 5.00 pm is the office hours operating time. During night, the power consumption remains low because most of the electrical appliance turns off. Air-conditioning is also turning off automatically every day after 10.00 pm. Only some equipment will operate 24 hours such as corridor lighting and water cooler.

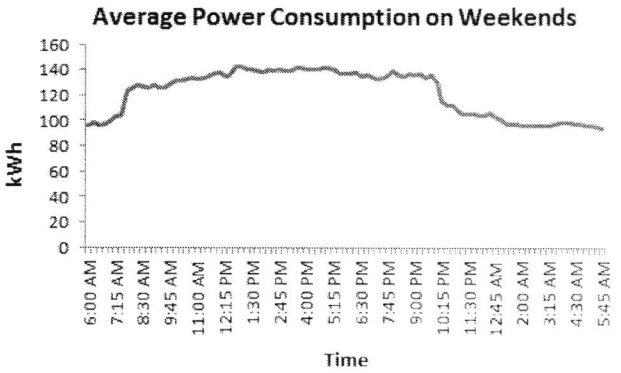

Figure 5: Average Power Consumption on Weekends (January 2013)

Figure 5 shows the average power consumption on Weekends at Block 3 during holiday. The energy consumption is below than 140 kWh for the whole day. During weekends, most of the classes and offices are close. Only corridor lighting and water cooler operate 24 hours same as during weekdays.

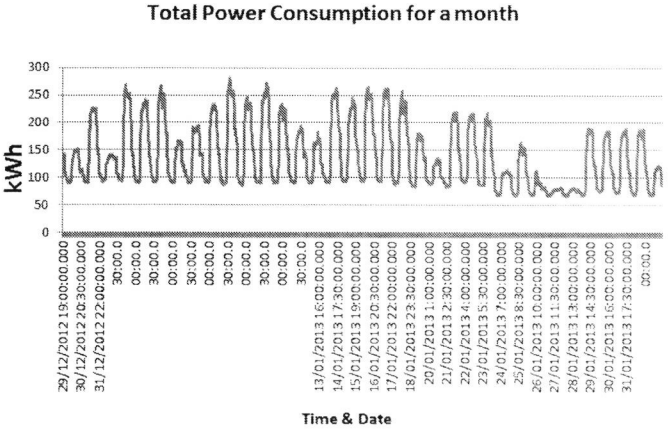

Figure 6: Total Power Consumption for a month (January 2013)

Figure 6 shows the total power consumption for a January 2013 at Block 3 which is during the holiday. During weekends, the graph shows a low level of power consumption same as mention earlier.

Part 2: Normal Operating month(December 2012)

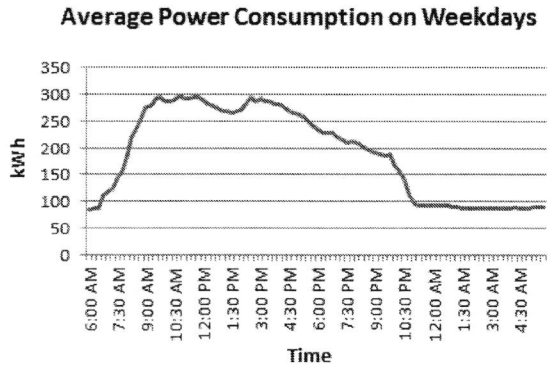

Figure 7: Average Power Consumption on Weekdays (December 2012)

Figure 7 shows the average power consumption on Weekdays at Block 3 during the normal operating month. During this month, the power consumption is higher than holiday. The maximum average power consumption is 300 kWh. From the graph, the power consumption starts increasing at 7.15 am. At this time, most of electrical appliances start to operate. At 12.00 pm until 2.00 pm, the power consumption decreasing a little bit due to the lunch hour. After 5.00 pm, the power consumption begins to decrease. Same as a holiday but at this month, all classes and lab are operated. That is the reasons why energy consumption during normal operating month is higher than the holiday.

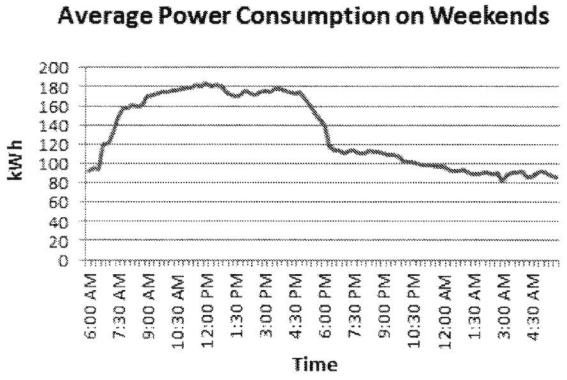

Figure 8: Average Power Consumption on Weekends (December 2012)

Figure 8 shows the average power consumption on Weekends at Block 3 during normal operating month. The power consumption is below than 180 kWh for the whole day. During weekends, most of the classes and offices are close. Only corridor lighting and water cooler operate 24 hours same as during weekdays. The energy consumption on weekends should be lower because no one should be in the building during holidays. Increasing in energy consumption during the holiday is due to student activities such as Kemahiran Insaniah. The other reason is due to library operating hours. The library is also open to students on weekends which is from 8:30 am to 5:00 pm. The increase of energy consumption during weekends also due to the students who preparing for examination.

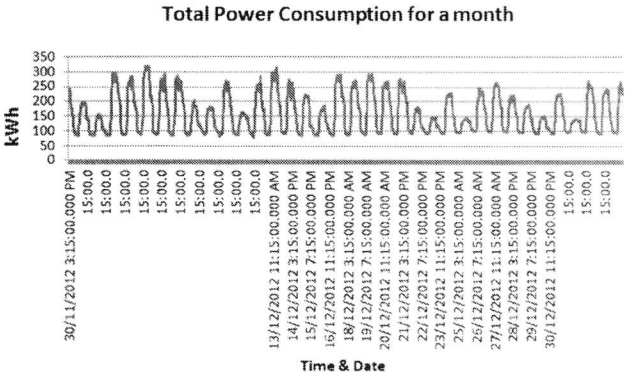

Figure 9: Total Power Consumption for a month (December 2012)

Figure 9 shows the total power consumption for a December 2012 at Block 3 which is during the normal operating month.

Total energy consumption per month for holiday and during the normal operating month is shown in Figure 6 and Figure 9. Our expectation is the energy consumption during the holiday is lower than the normal operating month. It is proven by the result obtained. From the result shown in Figure 6 and Figure 9, the energy consumption during the holiday is lower than the normal operating month.

D. Comparison of energy consumption before and after applying the potential saving

From the previous studies that being done in Unit Fasiliti, the potential energy saving is estimated 20% to 30%. Potential energy can be defined as how much energy can be saved after applying energy efficiency. The potential savings are estimated by implementing energy efficiency concept to all loads. The R22 gas of air-conditioning is replaced with R22 cold gas. It is because, R22 cold gas has a high efficiency. The existing lighting which is Fluorescent Lamps should be replaced with Light Emitting Diode (LED) Lamps. By using LED Lamps, the energy saving can increase up to 50%. The number of Lamp used every corridor also should be reduced. Shut down all computers when not in use also one of the methods to increase the energy saving.

If the same method is applied at the Tower 3, the same result can be achieved. Figure 10 shows the estimated energy consumption before and after applying all the methods as mention above. The potential energy saving estimated up to 30%.

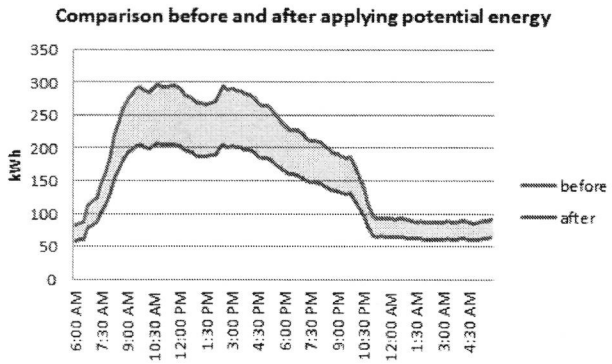

Figure 10: Comparison before and after applying potential energy

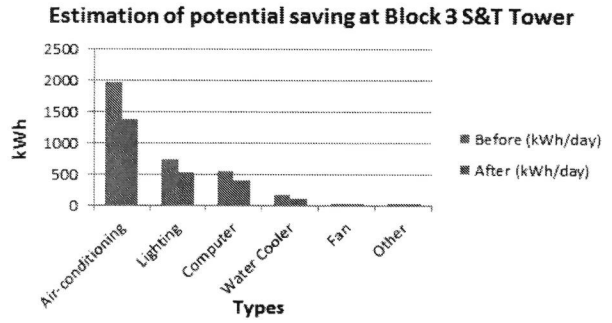

Figure 11: Estimation of potential saving at Block 3 S&T Tower

Figure 11 shows the estimation of potential savings at Block 3 S&T Tower by each load based on group assigned earlier. The power consumption for each load before and after applying potential energy is shown in Table 3. All energy saving is estimated at 30%.

Table 3: Comparison before and after applying potential energy

Types	Before (kWh/day)	After (kWh/day)
Air-conditioning	1970.65	1379.45
Lighting	737.46	516.22
Computer	553.50	387.45
Water Cooler	161.28	112.896
Fan	22.97	16.079
Other	12.58	8.81
Total Energy	3458.44	2420.91

Table 4: Electricity Bill Before and After Applying Potential Saving

Items	Unit	Before Applying Potential Saving	After Applying Potential Saving
Power Consumption per month	kWh/month	118323.0	82826.1
Electricity Tarif B	RM/kWh	0.312	0.312
Cost per month	RM/month	36916.77	25841.74

Table 4 shows that the electricity bills can be measured by the giving electricity tariff before and after applying potential energy.

IV. RECOMMENDATION

A sticker "switch off when not in use" should be provided in all places to remind users about energy saving. For the PLK program, it is recommended to do the courses in the same building for the whole UiTM Shah Alam. By applying this, UiTM's electrical bill can be reduced.

More recommendation is provided below based on electrical appliances.

A. Air-conditioning

Air-conditioning is a major or the highest energy consumption in Block 3 S&T Tower. It is recommended to replace R22 gas with R22 cold gas. R22 cold gas can reduce about 42% of energy usage. Another option is by decreasing the temperature of the air-conditioning. In this part, management team plays a main role. The ideal temperature must be set not less than 24°C. The air-conditioning also should be serviced on time. By applying this, the energy consumption can be reduced.

B. Lighting

Most of the lighting is operated 24 hours especially corridor lighting. It is recommended to have a controller such as sensor to control the light operation. Some of the area placed too much lighting. The number of lighting can be reduced to certain amount based on the Lux cover the area. For example at the corridor and toilet, the maximum Lux needed is only 100 Lux. By replacing Fluorescent Lamp with Light Emitting diode (LED) Lamp, the energy consumption in Block 3 can be reduced. LED Lamp has more efficiency than Fluorescent Lamp. It also does not contain toxic substances and have lifespan 10 times higher than Fluorescent Lamp. [9] Table 4 show a recommended average Lux level based on MS 1525:2007.

Table 4: Recommended average Lux levels

Task	Illuminance (Lux)	Example of Applications
Lighting for infrequently used area	20	Minimum service illuminance
	100	Interior walkway and car-park
	100	Hotel bedroom
	100	Lift interior
	100	Corridor, passageways, stairs
	150	Escalator, travellator
	100	Entrance and exit
	100	Staff changing room, locker and cleaner room, cloak room, lavatories, stores
	100	Entrance hall, lobbies, waiting room
	300	Inquiry desk
	200	Gate house
Lighting for working interiors	200	Infrequent reading and writing
	300 – 400	General offices, shops and stores, reading and writing
	300 – 400	Drawing office
	150	Restroom
	200	Restaurant, Canteen, Cafeteria
	150 – 300	Kitchen
	150	Lounge
	150	Bathroom
	100	Toilet
	100	Bedroom
	300 – 500	Class room, Library
	200 – 750	Shop / Supermarket/Department store
	300	Museum and gallery
Localised lighting for exacting task	500	Proof reading
	1000	Exacting drawing
	2000	Detailed and precise work

C. *Computer*

The management can encourage strategic steps to reduce energy consumption. All the staff and students are recommended to shut down the computers and monitors when not in use. There is a large amount of wastage by this equipment. From the observation, a lot of computers still turn on during a lunch time where there was no operation at that time. During these times, computer equipment should be switched off to prevent standby power being consumed. Staff and students play important role about awareness of energy consumption.

D. *Other electrical appliances*

Other electrical appliances consist of water cooler, television, freezer and many more. Some of the equipment operated 24 hours per day. It is recommended to have a control device such as timer to reduce energy consumption especially during no people in Block 3 which is during midnight or weekends.

V. CONCLUSION

For the conclusion, by implementing energy efficiency in the buildings, it can reduce the energy assumption and lead to reduce the electrical bill and wastage in Block 3 S&T Tower. Energy efficiency also can be applied to the whole building in UiTM Shah Alam. The main problem is the cost for installation is quiet high. Human behavior is one of the important factor to reduce energy wastage. They must be responsible and help to reduce the wastage of the energy. They should turn off all the equipment's such as air-conditioner, computer and lighting when not in used. It can be concluded that human behavior itself is a main factor to reduce energy wastage. Equipment's such as air-conditioner, lighting, computers and others that have implemented the energy efficiency can save cost. It is recommended that a program such as an Artificial Neural Network (ANN) using MATLAB can be created for future studies related to this project. By using this software, the implementation of energy efficiency can be measured easily.

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