Potential reduction of energy consumption in public university library

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Abstract. Efficient electrical energy usage has been recognized as one of the important factors to reduce cost of electrical energy consumption. Various parties have been emphasized about the importance of using electrical energy efficiently. Inefficient usage of electrical energy usage lead to biggest factor increasing of administration cost in Universiti Tun Hussein Onn Malaysia. With this in view, a project the investigate potential reduction electrical energy consumption in Universiti Tun Hussein Onn Malaysia was carried out. In this project, a case study involving electrical energy consumption of Perpustakaan Tunku Tun Aminah was conducted. The scopes of this project are to identify energy consumption in selected building and to find the factors that contributing to wastage of electrical energy. The MS1525:2001, Malaysian Standard - Code of practice on energy efficiency and use of renewable energy for non-residential buildings was used as reference. From the result, 4 saving measure had been proposed which is change type of the lamp, install sensor, decrease the number of lamp and improve shading coefficient on glass. This saving measure is suggested to improve the efficiency of electrical energy consumption. Improve of human behaviour toward saving energy measure can reduce 10% from the total of saving cost while on building technical measure can reduce 90% from total saving cost.

1. Introduction
Energy sources are among one of the basic requirements that have been used since the existence of human on earth. Rapid development of human civilization demands huge usage of energy resources of the non-renewable type. According to the International Energy Agency, energy demand is growing at a faster rate of 36% between 2008 and 2035[1]. Efficient usage of energy is one approach that is being studied and implemented. As Malaysia moves towards the status of a developed nation in 2020, our energy requirement will become more intensive energy consumption are divided into several main sector which is building, commercial, industrial and transportation [2]. Building sector is the among the major energy consumers in this country. Rapid growth of University Tun Hussein Onn Malaysia (UTHM) leads to an increase of electrical energy usage. It is expected that the university will expand six times greater than the current condition. Hence, it is crucial to study on the potential reduction of energy consumption. The objective of this study is to investigate the potential reduction of energy consumption, to investigate the cause of wastage electrical energy and to propose steps or opportunities for energy saving consumption.
2. Case Study
Tunku Tun Aminah Library building was selected as a case study in this research. The library building located in main campus of UTHM, Parit Raja, Batu Pahat, Johor, at 2° toward North and 103° toward East. The library building block is five stories building. The total floor area of the building is 16,000 m² and capable to occupied 4000 student capacity. This library was design to storage 300,000 pieces of books. The typical equipments used in this library building are including air conditioner units, lamps, computers, laptop, photocopy machine, printers and other small equipments. The building is oriented in a way that the longitudinal axis of the building is aligned with North West – South East axis. UTHM Library is shaded from North East and South West exposure due to presence of adjacent buildings. Table 1 shows the details of general information of the library building.

| No | Building Specification | Description |
|----|-------------------------|-------------|
| 1  | Area                    | 16,000 meter square |
| 2  | Storey                  | 5 storey building |
| 3  | Year Built              | May 2010     |
| 4  | Student Capacity        | 4000 people  |
| 5  | Storage Capacity        | 300,000 books |
|    |                         | 2 x seminar rooms, 100 x carrel rooms |
| 6  | Amenities               | 40 x discussion rooms, 1 x auditorium |
|    |                         | 2 x 24 hours reading room |

The library building operation can be categories into three main purposes. First purpose is to provide study area to the university students. Second purpose is to provide teaching and learning activity, such as seminar rooms and auditorium. Third purpose is function as administration office for top management, discussion room and meeting room.

3. Analyses

3.1. Electrical energy consumption pattern
Electricity consumption in Tunku Tun Aminah Library was studied by analyzing the actual electricity consumption of the electric bills issued by TNB. Electric tariff bills are issued in the early of every month to UTHM through Pejabat Pentadbiran Hartabina. Table 2 shows the detail of electric bill 2016 for Tunku Tun Aminah Library Building. Based on that table, the trends of electricity consumption from January 2016 to December 2016 are not consistent. In August 2016, the electricity consumption was only at 230,552kWh. It is the lowest electricity consumption because mostly students are not in UTHM due to semester break. However in March 2016 the electricity consumption reach up to 417,980kWh, highest compare to another month. Air conditioning contributes to a major portion of the electricity bill. The electricity energy consumption for air conditioning includes air conditioning for office rooms, class rooms, and lecture hall. Electricity consumption for lighting consists of office room, passageway, walkway, lobby, building and landscape lighting.

Based on research conducted by Z Noranai (2008), the breakdown of electricity consumption for air conditioning is 75% followed by electricity for lighting and other equipments is 25% [3].
Table 2. Detail electric bill year 2016 for Tunku Tun Aminah Library

| Month    | Electrical Consumption (kWh) |
|----------|-------------------------------|
| January  | 349,270                       |
| February | 292,400                       |
| March    | 417,980                       |
| April    | 393,740                       |
| May      | 401,420                       |
| June     | 370,690                       |
| July     | 307,164                       |
| August   | 230,552                       |
| September| 264,217                       |
| October  | 277,071                       |
| November | 303,641                       |
| December | 306,516                       |
| **Total**| **3,914,664**                 |

3.2. Cause of wastage electrical energy
Tunku Tun Aminah Library is one of the buildings that represent a very high energy consumption percentage compare to another UTHM building. In this study, several factors cause of wastage electrical energy is identified:

3.2.1. Usage of lighting at inappropriate area. Based on the observation conducted, it is found lamps at corridor and stairs way area are still on even thought that area already receive enough brightness from the sun. Lux meter equipment are been used for measuring brightness or luminance. The reading of lux meter at corridor area is 650 lux, exceed the lighting requirement of MS 1525:2007 which is 300 – 500 lux [4]. At stairs way area, the reading of lux meter also exceeds the requirement lighting needed for stairs which is 100 lux. The table 3 shows the amount of energy wastage due to using light at inappropriate area.

Table 3. Amount of energy waste with type of waste

| No | Type of Waste                      | Amount of energy waste per month (kWh) | Amount of energy waste per year (kWh) |
|----|-----------------------------------|----------------------------------------|---------------------------------------|
| 1  | Usage of lighting at inappropriate area – Corridor | 168.48                                 | 2021.76                               |
| 2  | Usage of lighting at inappropriate area – Stairs way  | 339.36                                 | 4720.32                               |
3.2.2. Airflows. Air flows or air leakage is one of the cooling load components. Air leakage occurs when outside air enter and conditioned air leaves uncontrollably through cracks and openings [5]. This factor will cause the increasing of cooling load and electricity consumption. After the observation is conducted, some of the causes of air leak was identified which is toilet doors at floor 4 and windows at locker area are left open. Table 4 below show the energy loss due to air flows.

Table 4. Amount of energy waste with type of waste

| No | Type of Waste                  | Amount of energy waste per month (kWh) | Amount of energy waste per year (kWh) |
|----|--------------------------------|----------------------------------------|---------------------------------------|
| 1  | Airflow – Toilet door          | 62                                     | 744                                   |
| 2  | Airflow – Windows              | 28                                     | 336                                   |

3.2.3. Usage of air conditioning in unused room. The use of air conditioning in unused room will contribute to wastage electrical energy. Based on observation conducted, it is found Permata Hikmah Library using air conditioning for 13 hours even though that library only operates for 3 hours per day. This library is supposed to using split unit air conditioning to control the room temperature inside. The table 5 below show the amount of energy wastage due to this factor.

Table 5. Amount of energy waste with type of waste

| No | Type of Waste                          | Amount of energy waste per month (kWh) | Amount of energy waste per year (kWh) |
|----|----------------------------------------|----------------------------------------|---------------------------------------|
| 1  | Usage of air conditioning in unused room | 4100                                   | 49200                                 |

3.2.4. Misuse of electric equipment. Ground floor contain 24 hours study room that operating every day. There are several facilities provided such as fan, air conditioner, table and chair. Based on observation conducted, some of users still switch on the fan even though the air conditioner is already operating. This situation will contribute to the waste of electricity. The table 6 below show the amount of energy wastage due to this factor.

Table 6. Amount of energy waste with type of waste

| No | Type of Waste                  | Amount of energy waste per month (kWh) | Amount of energy waste per year (kWh) |
|----|--------------------------------|----------------------------------------|---------------------------------------|
| 1  | Misuse of electric equipment   | 540                                     | 6480                                  |
3.3. Energy saving opportunity
Key figures for energy consumption and energy saving potential for Tunku Tun Aminah Library were presented based on observation, review of relevant literature and calculation conducted. As a result, it can be concluded that the main energy consumption is the air conditioning system followed by lighting system. There are several energy saving approaches including minimize the lamp number, minimize the lamp usage, put a sensor and change the lamp type. Table 7 illustrated the amount of energy saving with its type of saving.

| No | Saving action | Amount of energy saving per month (kWh) | Amount of energy saving per year (kWh) |
|----|---------------|------------------------------------------|---------------------------------------|
| 1  | Change the fluorescent type of lamp in toilet into LED tube lamp type. | 1,950 | 23,400 |
| 2  | Change the fluorescent type of lamp in closed space into LED tube lamp type | 3089 | 37,068 |
| 3  | Installing the Sensor | 2,238 | 26,856 |
| 4  | Reduce the number of lights in the Open reading space | 17,355 | 208,260 |
| 5  | Enhancing Layer Window Films | 32,160 | 385,920 |
|    | **Total**     | **56,792**                               | **681,504**                           |

As an example potential energy saving calculation method

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\text{Fluorescent lamp Energy} = \text{Number of lamps x power x hours} = 500 \text{ pieces x 32 watts x 2600 hours} = 4160 \text{ kWj}
\]

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\text{LED lamp energy} = \text{Number of lamps x power x hours} = 500 \text{ pieces x 17 watts x 2600 hours} = 2210 \text{ kWj}
\]

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\text{Potential energy saving} = \text{Fluorescent lamp Energy} - \text{LED lamp energy} = 4160 - 2210 \text{ kWj} = 1950 \text{ kWj per month.}
\]

4. Conclusion and recommendation
There are two types of potential cost saving; with less or no costs and with costs whether medium costs or high costs. Rescheduling of air conditioner system and lighting operation is consider as no costs potential saving per year. Retrofitting specific lighting system typically would bring great saving up to RM8990 per month, but this measure is required medium initial investment costs. Increasing the
shading coefficient of window film will save up to RM11680 per month. As conclusion, if all the recommendation made are implemented, it is estimated possible to save up to RM20279 per month. It is suggested for further economical analysis to find out payback period and return of investment.

Reference
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