Energy audit for lighting in an academic building – Case study in UTeM

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ABSTRACT - Lighting is essential for both domestic and industry usage. In Malaysia, it was estimated lighting used approximately 20% of the total energy total consumption of buildings and has potential for energy saving opportunities and achieves energy efficiency apart from good operational practices.an Energy audit is a tool used to assess and identify lighting energy consumption in the specified building or area. In this project, the energy audit focuses on the lighting systems in a FKM academic building at Technology Campus. By understanding the current lighting system condition and energy data analysis, It can help in evaluating the current performance of the lighting system. Energy reprofit is proposed to accommodate the occupant usial confort and performance. Mostly the lighting levels in every audited zone exceed Malaysian Standard MS 1525:2014.

1. INTRODUCTION

Electrical energy is very important in human life, but much of it content is wasted by inefficiencies in the energy conservation and distribution processes. Building's energy used accounted for the largest share of the final energy use by the commercial and residential sector. Air conditioners are shown to be the major energy users (57%) in office buildings, followed by lighting (19%), lifts and pumps (18%) and other equipment (6%) [1].

The global contribution from buildings towards energy consumption, both residential and commercial, have steadily increased, reaching figures between 20% and 40% in developed countries. Growth in population, increasing demand for building services and comfort levels, together with the rise in time spent inside buildings, assures the upward trend in energy demand will continue in the future. For this reason, energy efficiency in buildings is today a prime objective for energy policy at regional, national and international levels [2].

Stable illumination is a vital part in an interior environment. It is impossible to create a pleasing environment without proper lighting. Illumination is essential to identify and define an interior. Light helps to define an interior in terms of spatial size, depth, ambience and appearance. An energy audit is an evaluation of energy consumption in a domestic, commercial, or any other premises. It is generally used to determine where energy can be saved, conserved or used more efficiently [3].

2. BACKGROUND

Chia et al.[4] showed analysing some cases of the structure of electric consumption and electric facilities of the official buildings. The lighting load is the second biggest load of the studied building and is substantially saved if the efficiency of luminaries selection is used with the supplementary artificial lighting. Most existing lighting systems were designed without considering energy efficiency. Finally, this action saves replacing element cost and maintenance fee and the power factor of electronic ballasts is more than 95%, thus, it can reduce the current and improve user's safety. This action also can enhance circuit stability and reduce power line loss.

Ravi et al.[5] Studied on the efficient illumination design and occupancy of the main building of Asia Pacific, University of Technology and Innovation (APUTI).

It resulted in a total power saving of 16.59kW per day and 11 hours taken as the normal operating hours (7:30am to 6.30pm) for which an energy saving of 182.9 kWh has been achieved. Average annual energy saving of 50,000kWh has been achieved excluding weekends and public holidays (around 255 days), which contributes to 2.28% of the total energy consumption. The authors concluded that a total of 67520kWh is saved by the above two methods which contributes to 3.08% of the total energy consumption.

3. METHODOLOGY

In this work, the building is divided into many areas like, lobby room, corridors, meeting room, office room, lecturer room, and library. The normal operating hours for FKM's academic building ground floor and first floor start from 8.00 am until 5.00 pm depending on the classes' timetable and mainly used during weekdays.

A proper observation in the academic building is based on visual verifications such as the lighting system arrangement, occupant behavior on lighting usage and type of lighting lamp used for each zone area.

Once the data successfully gathered, digital lux meter used to conduct lighting measurement in each zone area by placing it in the specific zone at about 0.8 meters above the ground level. The lighting system

energy data analysis can be done upon the types of lamps for each zone is specified. The analysis involves the electricity usage of FKM's academic building, comparison a certain period of time and the approximate total of the average cost of the academic building's. Power density can be calculated as using the equation (1).

$$\textit{Power Density } (W/m^2) = \textit{Lamp Capacity } (W) / \textit{Area } (m^2) \quad (1)$$

For each zone, the data can be used to calculate the amount energy consumed during observation period from 8.00 am to 5.00 pm. The data collected from all floors building to calculate the amount of energy consumed by the lighting and the operating cost unit can be calculated as in equations (2) and (3) respectively:-

$$\text{Energy usage} = \text{Power (Watt)} \times \text{Total Operating Hours (Hour)} \quad (2)$$

$$\text{Cost} = \text{Energy usage (kWh)} \times \text{Electricity tariff (cent per kWh)} \quad (3)$$

The Building Energy Index (BEI) is the most commonly used for comparing energy in buildings as shown in equation (4):-

$$\text{FKM Building Energy Index} = \text{Total Energy usage for 2013 Nov. to 2014Oct} \; / \; \text{Total FKM Gross Floor Area} \quad (4)$$

4. RESULTS AND DISCUSSION

The energy consumption was calculated based on the wattage capacity and its operation during office hours period. The wattage capacity from each zone for both floors was accumulated and the data used to obtain the energy consumption estimation. Table 1 shows the estimated energy consumption for all floors and total electricity cost.

Table 1 Energy consumption estimation for all floors.

Floor	kWh per month before retrofit
Ground	2177.28
First	1703.52
Second	4163.52
Third	4464.80
Fourth	2598.72
Fifth	4483.44
Sixth	4440.48
Total	24131.76
Cost (MYR)/month	8928.7512

The energy saving calculation involved the difference before and after retrofit plan. Table 2 shows the proposed retrofit plan to implement on the all floors.

Table 2 Comparison before and after retrofit proposal.

Before retrofit	After retrofit	Floors Involved
Currently using 36 W fluorescent lamps (TL-D 36W)	Change to 28W High Efficiency fluorescent lamps (TL5)	All Floors
Operating hours- 9 hours	Change to 8 hours (1 hours –switching off during break time)	All Floors
Maintain 18 W Recessed mounted channel fluorescent fitting (TL-D 18 W)	Maintain 18 W Recessed mounted channel fluorescent fitting (TL-D 18 W)	All Floors

The new energy consumption after retrofit plan has been calculated and lighting electricity cost per month are listed as in Table 3.

Table 3 Energy Consumption Estimation for each floor after retrofit plan.

Floor	kWh per month before retrofit	kWh per month after retrofit
Ground	2177.28	1753.9
First	1703.52	1361.2
Second	4163.52	3337.9
Third	4464.80	3388.8
Fourth	2598.72	2191.7
Fifth	4483.44	3642.5
Sixth	4440.48	3664.8
Total	24131.76	19,940.80
Cost (RM)/month	8928.7512	7378.096

5. CONCLUSIONS

The highest electricity usage was recorded in April 2014 and energy consumption of 668.707 kW hand lower electricity usage was recorded in November 2013 525.776 kWh. The energy consumption fluctuates throughout the year except from November 2013 to October 2014 almost constant recorded energy consumption range between 525.776 kWh and 668 kWh. From preliminary analysis, FKM academic building fifth floor consumed the largest a mount of energy is about 4483.44kWh per month. Quantitatively, the electricity usage consumed about 24131.76 kWh per month and costing MR 8928.75 per month. The feasibility measures to save energy and money can be applied in the FKM academic building. By implementing the proposed retrofit by replacing the current lamps to 28W High Efficiency fluorescent lamps (TL5), it can save energy and reduce electricity bills. From the calculation, it can save almost 4190.96kWh per month, which accounted about MR 1550.65 per month. Annually, it can save abuot MR 18607.77 equivalent to approximately 1.5 years of the simple payback period and 75.6% simple rate of return.

6. ACKNOWLEDGEMENT

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