Preliminary Study of Energy and Cost Saving Potential of Lighting System in Teaching Building

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Abstract
Energy consumption and potential for energy savings become more intensive in public buildings in order to improve energy performance. This study will identify the current occupancy, lighting use patterns and lighting performance in G3 Block B teaching building of University Tun Hussein Onn Malaysia. In order to determine the energy saving potential and strategies for lighting system in the building, a series of data collection will conduct to the effects of occupancy and lighting use patterns to display the lighting energy consumption and notice to the lighting energy waste of the case study building. Moreover, lighting performance of the teaching building is also been measured to identify potential of improving the usage of lighting system. Based on the experiment data obtained, there are 36% - 46% of the total hour usage of lighting system are needlessly in the unoccupied lecture rooms. The energy and cost saving potential strategies are suggested to improve the usage and efficiency of the lighting system in the teaching building towards energy conservation.

Keywords: Energy, Lighting, Teaching building

1.0 Introduction

Energy consumption and the potential for energy savings become more intensive in residential, industrial, commercial and public buildings to improve energy performance nowadays. Energy consumption is growing as construction booms, particularly in countries such as China and India (Zhang et al., 2011). According to Elmuradov et al. (2015), one of national energy policy's objectives in Malaysia is to promote efficient utilization of energy and the elimination of wasteful and non-productive patterns of energy consumption. In any organization, electricity usage should be analysed to identify unwanted and unnecessary usage, which would create the opportunities to find waste and initiate solutions to reduce it. Investing and implementing energy saving practices, energy management and conservation will greatly contribute toward reduction in electricity cost but more importantly use the electrical energy in the most diligent way and reduce wastage in energy use. Figure 1 shows the operation and building maintenance in public university.

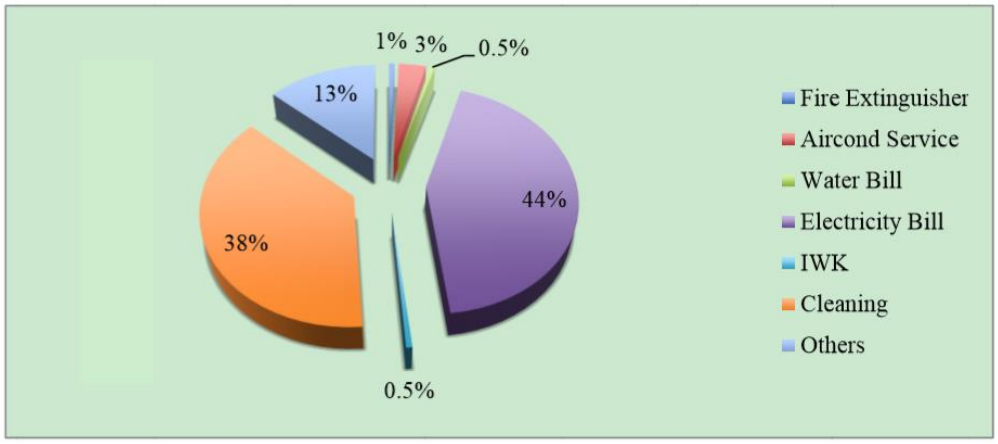

Figure 1: Operation and building maintenance in public university (Elmuradov et al., 2015)

Lighting is one of the largest users of electrical energy in a typical commercial building (Von et al., 2001) that accounts for 5–15% of the total electric energy consumption (Yun et al., 2012). Lighting is a key issue in minimizing overall energy consumption of building and energy consumption of a lighting installation is strongly dependent on lighting controls usually related to daylight and occupancy detection (Ryckaert et al., 2010). In both new and old buildings today, there are countless opportunities and various energy-efficient lighting technologies that are introduced to improve lighting efficiency and to minimise the cost of energy used.

Nowadays the higher probability of energy wastage is mainly caused by the user's negative energy use behaviour in a building (Sheau Ting, 2012; Dubois et al., 2015). Increased electrical energy usage in University Tun Hussein Onn Malaysia every year that end up with huge cost of electricity bill was due to the rapid growth of the university's activity (Noranai, 2011). The teaching rooms are involved in this study since they consume the greatest item of energy, comfort and well-being of students which are the main objectives pursued in educational environment.

It is normal to observe that building users do not diligently turn lights off when they vacated spaces, with the lighting system in an empty classrooms. Consciousness and intention of building users are not strong and causing unnecessary wastage of energy consumption to a building. Thus, this produces the opportunity to analyse the energy usage of teaching room and identify the potential energy reduction and cost savings. Moreover, there is great need to promote intention of user's behaviour change to ensure they switched off the electric loads when the users were out of the room.

The wall switch lights which need manual controlled are usually turned on by users as they enter the room, but not usual turned off as they vacate. Users may not hesitate and unwilling to turn off lights in a small room if they think someone else may still be in the space or enter again shortly. If those students do not turn off the lights when they leave for the day the organization

winds up consuming power for example 100 unnecessary lights for 3 hours each day. Then, the 36 watt fluorescent light left on for an additional 3 hours each day burns up RM3.94 of electricity per day or RM118.26 per month at 36.5 cents/kWh. The purposes are to determine and understand the energy usage pattern of the lighting system based on the occupancy data and amount of lighting operation data in the rooms for study.

1.1 Teaching Building

In general, university is the institutional buildings that situated a collection of buildings that used for either academic or non-academic which provides higher education and research, typically undergraduate education and postgraduate education. The university consists mainly of high rise buildings and structures, teaching building or academic building is one part of building in the university campus. There are the main structure that provide educational service delivery, specifically teaching and learning activity (Mehreen & Sandhya, 2014).

1.2 Lighting System

Lighting systems represent an important piece in the electrical system of overall building puzzle. Lighting systems convert electrical energy into light energy. All lights have a light bulb or commonly referred to as a lamp which connected to the energy source by fixture. In fluorescent and high intensity discharge (HID) fixtures, the energy supply must be modulated through a ballast. Thus, the combination of lamp, fixture and all others necessary ballast are called a luminaire (Tracy et al., 2011).

Lighting system are used to provide sufficient light inside buildings and also for security and beauty on the outside of buildings. Most importantly lighting systems are designed to create a comfortable and safe environment in buildings. Simple modifications of lighting systems can greatly reduce the energy used while still providing quality and illumination needed for various purposes.

1.3 Energy

Energy is the ability or capacity to perform work. Energy cannot be created or destroyed but can be converted from one form to another. For example, chemical energy in fossil fuels can be converted into electrical energy, and then the electrical energy can be converted into useful work in the form of heat, light, and motion. Energy is measure in watt seconds or joules which usually is expressed in thousand watt-hour or kilowatt-hour (kWh) nowadays (Brown & Sovacoal, 2011).

2.0 Methods and procedures

2.1 Experimental Space

This article is based on a case study of the occupancy, lighting use patterns and lighting performance of lighting system in G3 building Block B, *Universiti Tun Hussein Onn Malaysia*. G3 building located at the centre of the university

and constructed various type of teaching rooms and lecture halls with teaching facility. Thus, this teaching building is selected to be studied due to its high usage of teaching rooms by the users. The selection of case study building is determined by the following factors:

- This teaching building consists of the most amounts of teaching rooms in the campus.
- The existing lighting control system of this building is manually control by the users.

This building is free access by the users in the building operating hours resulting the users of the rooms are intermittent and unpredictable.

2.2 Experimental Procedure

Data for three rooms will originally collected for the monitoring period, start at 8.00a.m to 6.00p.m every day in the weekdays. The rooms for study included BK-BK8 on the first floor and BK-B9, BK-B10, on the second floor of the G3 Block B building. The rooms for study on first floor and second floor are selected due to lesser access and pass-by by the building users than the ground floor thus the lighting operation is more common to get ignored and neglected by the building user.

The total lighting load or amount of lighting operated in the room and the occupancy condition will be observed and recorded in every 30 minutes into a data collection form. The basic requirement for adequate lighting are that the work must be easy to see and the light comfortable to the eyes. To investigate the lighting performance, the illuminance level of artificial lighting installed in the room will be measured and analysed. The lighting performance is then determined whether meeting the comfortable illuminance levels and MS 1525:2007 recommended average illuminance of lighting for working interiors.

Extech 4-in-1 Environmental Meter, a type of lux meter is used to measure internal illuminance in this study. Firstly, the internal area or dimension of the room for study will be requested from facilities management division, *Pusat Pengurusan Harta, Universiti Tun Husseion Onn Malaysia*. The floor area is used to determine the necessary number of points needed to obtain an accurate measured average illuminance. To measure the illuminance level of the rooms, the methods to conduct the illuminance measurement is by Chartered Institution of Building Engineers, 2012. The data of average illuminance level obtained in this study are recorded and analysed to determine the energy saving potential and strategies for the lighting system in the building.

3.0 Results and discussion

The occupancy data is based on the four condition about occupancy pattern such as Table 1 and Table 2. Table 1 stated the condition of the occupancy which categorized as condition 1 to condition 4. Meanwhile, Table 2 shows the status of occupancy. It is categorize into another three occupancy status, namely CLASS, EMPTY and MISUSE. The collection of status of

occupancy data ease up the analysis of total hour usage and energy use of lighting system. Status of CLASS is meant to the room is occupied and used for attending a class or teaching and learning activities. EMPTY is meant to the room is unoccupied by any building user.

Table 1: Types of data required for occupancy condition

Condition	Description
1	Occupied with the lights on
2	Occupied with the lights off
3	Unoccupied with the lights on
4	Unoccupied with the lights off

Table 2: Types of data required for status of occupancy

Status	Description
CLASS	Room is occupied for class with lights on or off.
EMPTY	Room is unoccupied with lights on or off.
MISUSE	Room is occupied with unnecessary lights on or off.

As mentioned, there is a specific condition that is emphasized in this study which is MISUSE status. The building users sometimes misuse the lighting for the activities that switch on the excessive and unnecessary number of lighting in the room. For example, one or two users in the room is switched on the entire lighting for the activities like resting or discussion which excessive lighting operation can be avoided. These statuses of condition will be observed for the aid of determining the influence and awareness of the user behaviour towards energy conservation.

For the lighting energy cost calculation, the total load for each room will apply to investigate the actual lighting energy use and waste. Thus, the data collected from the direct observation of occupancy and lighting use patterns in the monitoring period are used to calculate the lighting energy cost. According to the study by Bill et al. (2001), the same methods of calculating the lighting energy use and waste are applied for determine the lighting energy cost in this case study.

- Lighting energy use is calculate by multiplying the total lighting load by the time that the lights are switch on and the room is occupied (CLASS).
- Lighting energy waste is calculate by multiplying the total load by the time that the lights are switch on and the room is unoccupied (EMPTY).
- Lighting energy misuse is calculate by multiplying the total load by the time that the lights are switch on and the room is occupied unnecessary (MISUSE).

Accordingly, the results showed that the total hours usage of classroom BKB8 is 59.93% (class); 36.03% (empty); 4.04% (Misuse). For the classroom BK9 is 40.75% (class); 45.75% (empty); 13.5% (Misuse). While the classroom

BKB10 45.42% (class); 44.37% (empty); 10.21% (Misuse). For more detail, please refer to Table 3.

Table 3: lighting reading

	Status of classroom – BKB8			Status of classroom – BKB9			Status of classroom – BKB10		
Day	Class	Empty	Misuse	Class	Empty	Misuse	Class	Empty	Misuse
Day 1	216	468	36	324	252	0	279	108	18
Day 2	279	216	0	216	198	72	360	180	153
Day 3	441	99	0	252	180	36	153	234	36
Day 4	504	90	36	114	288	216	369	0	54
Day 5	162	90	36	72	180	0	0	612	0
Total	1602	963	108	978	1098	324	1161	1134	261
Hours	59.93	36.03	4.04	40.75	45.75	13.5	45.42	44.37	10.21
Usage	%	%	%	%	%	%	%	%	%

4.0 CONCLUSION

Based on the pilot study that has been conducted, we can observed there are 36% - 46% of the total hour usage of lighting system are needlessly in the unoccupied lecture rooms. Thus, it is crucial to analyse the energy usage of lighting system in teaching building for identification of potential energy reduction and cost savings. Apart from that, the intention of user's behaviour towards energy conservation can be done by raising the energy awareness and improve energy-use behaviour among the students by their behavioural improvement.

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