MEASUREMENT OF BUILDING ENERGY INTENSITY TOWARDS POTENTIAL OF BUILDING RETROFIT FOR M50, UNIVERSITI TEKNOLOGI MALAYSIA

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To my beloved mother, father, family and him

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ABSTRACT

As Malaysia aims to become a developed country, tremendous development cause the electrical energy consumption to increase. This consumption is somehow can be reduced by implementing energy efficient technology in the new and existing building. With this effort, it will help to reduce energy consumption and electricity costs spend by the building. The aim of this study is to identify the Building Energy Intensity (BEI) towards potential for retrofitting initiatives, M50 building in Universiti Teknologi Malaysia. The first approach was by studied the recent energy consumption, layout of floor area, information of electrical equipment (type, power and frequency of the usage) and also the energy efficient technologies that were installed of M50. The data collected were used to identify the actual BEI which then was compared with the monthly building energy index. The result showed that the demand of building energy intensity was not reached maximum utilization. The highest utilization of energy recorded was only 40%. In order to understand the nature of electrical usage by the occupants, a set of questionnaires were distributed. From the feedback of the questionnaires, the building user possessed positive behaviors toward energy saving. They were also satisfied with the performance of electrical appliances and facilities in the building. Besides that, majority of the occupants preferred solar photovoltaic (PV) to be installed at the building as priority option of retrofitting technology. Therefore, a series of interviews with the qualified PV service provider companies were conducted. The implementation cost for the solar system is RM 129,600 with the return of investment 26.0 to 21.9 % for the range from 1 to 22 years and the payback period is 3 years and 11 months.

ABSTRAK

Memandangkan Malaysia berazam untuk menjadi sebuah negara maju, pembangunan pesat telah menyebabkan penggunaan tenaga elektrik meningkat. Penggunaan ini dapat dikurangkan dengan melaksanakan teknologi cekap tenaga di dalam bangunan baru dan sedia ada. Dengan usaha ini, ia akan membantu untuk mengurangkan kos penggunaan tenaga elektrik oleh bangunan tersebut. Tujuan kajian ini adalah untuk mengenal pasti Intensiti Tenaga Bangunan (BEI) ke arah potensi untuk diubah suai. Bangunan M50 di Universiti Teknologi Malaysia. Pendekatan pertama ialah mengkaji penggunaan tenaga semasa, luas permukaan lantai, maklumat peralatan elektrik (jenis, kuasa dan kekerapan penggunaan) dan juga teknologi cekap tenaga yang telah dipasang di M50. Data yang dikumpul telah digunakan untuk mengenal pasti BEI sebenar yang kemudiannya dibandingkan dengan indeks tenaga bulanan bangunan. Hasilnya menunjukkan bahawa permintaan intensiti tenaga tidak mencapai penggunaan maksimum. Penggunaan tenaga tertinggi dicatatkan hanya 40%. Untuk memahami sifat penggunaan elektrik oleh penghuni, set soal selidik telah diedarkan. Maklum balas daripada soal selidik ini mendapati bahawa pengguna bangunan itu mempunyai tingkah laku yang positif ke arah penjimatan tenaga. Mereka juga berpuas hati dengan prestasi peralatan elektrik dan kemudahan di dalam bangunan. Selain itu, kebanyakan penghuni memilih solar photovoltaic (PV) untuk dipasang di bangunan tersebut sebagai pilihan utama pengubah suaian teknologi. Dengan itu, sesi temu bual bersama syarikat yang berkelayakan sebagai penyedia perkhidmatan PV telah dijalankan. Kos pelaksanaan bagi sistem solar adalah RM 129,600 dengan pulangan pelaburan 26,0-21,9% untuk julat dari 1 hingga 22 tahun dan tempoh pembayaran balik adalah 3 tahun dan 11 bulan.

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AI	-	Average Index
BAS	-	Building Automation System
BEI	-	Building Energy Intensity
DDC	-	Direct Digital Control
FIT	-	Feed In Tariff
GBI	-	Green Building Index
LCC	-	Life Cycle Cost
PSH	-	Peak Sun Hour
RII	-	Relative Importance Index
ROI	-	Return Of Investment
VAV	-	Variable Air Volume
VSD	-	Variable Speed Drive

CHAPTER 1

INTRODUCTION

1.1 Research background

As Malaysia pursued to become a developed country in the year of 2020, multibillion ringgit development projects have been planned. The investment involving multiple disciplines which are among them is infrastructure development. The energy usage is expected to increase rapidly due to expansion of the economy (Lincoln, 2006). There are many factors that contributed to the increase of building energy consumption such as the increase in population, enhancement of building services and people comfort level, and also the increase of time spent inside the buildings. According to International Energy Agency, in the year 2030, the energy consumption will be increased by 53% whereby 70% will be come from the developing country such as Malaysia (Shafiea et. al, 2012). Energy has become one of the most essential inputs for social and economic development; it is a basic need in our modern life and contributes to nation's growth and development (Energy Policy of Malaysia, 2004).

As stated by Shafiea *et. a*l (2011), the energy demand in Malaysia is increasing from year 1999 to 2009 which are 9690 MW and 16132 MW, respectively. The ten year of time gap already shown 66.5% increment of energy demand, thus more electric energy production needed. The electricity provide the pleasure by variety of uses and energy services such as heating, ventilation, air conditioning, lighting, refrigerators and other electrical applicants. Electricity is produced by

converting energy from one form to electricity. There are various sources of energy which are fossil fuels, nuclear energy, solar radiation and hydro energy.

But, in Malaysia, most of the energy production is by using fossil fuel. In 2009, 94.5% of electricity in Malaysia is being generated by using fossil fuel such as natural gas, coal, diesel, oil and fuel oil (Shafiea et. al, 2011). The combustion of fossil fuels will release carbon monoxide, carbon dioxide, sulfur dioxide and nitrous oxide gases into the atmosphere. These 'greenhouse gases' contribute to acid rain and global warming effects as the more energy that being consume, the more it contribute to negative environmental effect. Therefore, the more efficient method to reduce the electricity in a building operation will surely help to protect our environmental and the increase of energy demand will exhaust the limited energy resources in the future.

Green buildings are designed to save energy and resources, recycle materials and minimize the emission of toxic substances throughout its life cycle. In 2011 at China, the experts has estimate that roughly about 200 buildings which mostly are the government buildings has certified the Three- Star Green Building Certification program which has been started in 2006 (Yifei, 2011). The tropical zones like Malaysia use Green Building Index or GBI as a rating tool to show that the building practiced the environmental design in their operation. GBI is intended to promote sustainability in the built environment and also as an initiative to lead the Malaysian property industry toward becoming more environmental friendly. One of the criteria that the building must have in order to be awarded is energy efficiency (Tan, 2009).

Energy efficiency refers to a reducing the energy consumption to an acceptable level of comfort, air quality and other requirements. By apply energy efficiency in building, it is not only can save the environment but also can give a financial rewards as it can save the building energy bills. It may be applied throughout the building from the roof, walls, or from needs and use patterns of lightning, electric equipment, heating and air conditioning. It is depends on geography, climate, building type and location of the building. The challenge application of energy efficiency are different between existing and a new buildings as for the existing

building, it require retrofitting. To retrofit an existing building, the challenges were mostly came from the technical difficulties and financial constraints (Surapong, 2003).

1.2 Problem Statement

Three main sectors that consume large electrical energy are industrial, transportation and service sector. The service sector includes all commercial and public building such as school, office, restaurant, hotels, hospitals, museums and others. According to Lombard (2008), office buildings are the biggest consumption of energy over 50% for non-domestic building. There are many factors that contribute to energy consumption in the office such as increase in total built area, amount of artificial lighting, electronic equipments, air conditioning area, and others. According to Pusat Tenaga Malaysia, majority office building in Malaysia had building energy index in a range of 200 to 250 kWh/m^2/year but the recommended building energy index is 135 kWh/m^2/year based on MS1525 standard. But, there are three buildings achieved Building Energy Index standard which is Low Energy Office (LEO) building, ST building and Zero Energy Office (ZEO) building (Zamri, 2012).

One of the government office buildings that must be given attention is university campus office building. Since 2007, the Ministry of Education Malaysia has urged all education centers to conserve energy because of energy wastage tend to occur in many Malaysian universities (The Star, September 13, 2007). Besides that, administrators in Malaysian universities also are concerned about the expensive monthly electricity bill. Both energy managers from Universtiti Teknologi Malaysia (UTM) and International Islamic University Malaysia (IIUM) have agreed that local universities nowadays are facing serious energy wastage problems. Energy cost more than ten million ringgit annually and this burdens the universities (Choong, 2009). Therefore, by reducing and manage energy usage can give benefit to the Malaysian university that confront expensive energy bill because of the large build up areas, comprehensive facilities as well as large number of building users. Thus, it is needed to identify the criteria of the potential building to be retrofit and which building has the most potential to be retrofit.

In Malaysia, there are 20 public university campuses. Majority of the campus have taken initiative to create a sustainable development. For example, in University Kebangsaan Malaysia (UKM), the land area is 20709 acre. There are 10 faculties and 11 colleges in the campus which can accommodate about 85% of the students' population. The university target is to achieve the sustainable campus status in year 2020. One of the criteria that help to develop the sustainable components at UKM is by managing energy efficiently and sustainably through reduces of energy usage, use alternative source of energy and usage of renewable energy (Zuhairuse, 2009). For the case of Universiti Teknologi Malaysia (UTM), now it has two campuses. The main campus is in Skudai, Johor Baharu, while the branch campus is situated in Jalan Semarak, Kuala Lumpur. The main campus of UTM has an area of 1,222 hectare that consists of 14 faculties, 12 college and other facilities. It is being taken reviewed on Faculty of Civil Engineering (FKA). In 2012, FKA has paid RM 1 061 905 of energy bills. So, it is required to identify if there is any potential for FKA to response for energy reduction through it building retrofitting and the amount of energy reduction. Besides that, by identified the initiative, cost, return of investment and payback period for the FKA building to be retrofit, it is useful for the building management to do further actions in order to be awarded as a green building.

1.3 Aims of Study

The aim of this study is to identify the building energy intensity (BEI) of M50 towards potential for retrofitting initiatives.

1.4 Objectives of Study

The study was done based on the several objectives that are:

i. To identify energy consumption of M50 building.
ii. To measure actual building energy intensity of existing building.
iii. To determine user behaviour, satisfaction and recommendation on reducing energy consumption.
iv. To analyse the cost, return of investment and simple payback period to propose retrofit for zero energy balance building.

1.5 Scope of the Study

This study was carried out at M50 building in Faculty of Civil Engineering, Universiti Teknologi Malaysia. It is purposely to determine the building energy intensity of the potential building to be retrofit in Faculty of Civil Engineering. The M50 building was selected because of the existing characteristics of the building already have energy efficient designed such as daylight utilization and shaded window. While, it also been retrofitted with motion sensor and lighting using T5 tube florescent lamp. However, the M50 building also function as a student laboratory thus it contribute to higher energy usage.

1.6 Brief of Research Methodology

The research methodology approach is adopted to ensure that this study can be executed accordingly. This study was carried out in several steps in order to achieve the research objectives. The detail explanation of the research methodology will be further clarified in Chapter 3, the research stage covered as follows:

i. Preliminary stage of study

First and foremost, further understanding of the study was done by identifying the problem or issue related to the study. It is followed by the determination of aim, objectives and scope of the study. The exploration of all information including literature review were executed through accessing the published journals, books, articles, previous thesis and other sources in order to get an overview of the study.

ii. Data collection and Analysis

For data collection, observation and record review were being conducted by collecting the energy billing in order to determine the overall energy consumption of the building. Besides, the in-situ energy audit also was conducted for determination of the type of equipment and machinery used in the building together with its effective hours of usage under typical operations and the power usage required. All the collected data were used to assist in finding the building energy intensity. The calculation of building energy intensity of the M50 building was carried out by using Microsoft Excel.

iii. Conclusion Stage

The determination of energy intensity will help in identifying the largest energy usage of the equipment and machinery in the building and also to determine the current demand of operation. Based on the energy intensity result, the proposed energy efficiency retrofit initiative that could be taken for the existing building will be determined. Besides that, the occupant recommendations of the retrofitting technology that's suitable to be implemented at the building was determined. Then, the cost of retrofit, return of investment and payback period were identified as to determine whether it is worth or not to invest in retrofit the building.

1.7 Expected Findings

This study leads to the potential of retrofitting the M50 building in Faculty of Civil Engineering as a zero energy building by providing several findings. The first expected finding is to figure out the current situation and condition of energy consumption in the building. It is important as the data will assist in finding the building energy intensity. The second findings is to get the building energy index of the building and also the amount of energy that can be save in the building. Besides, the third expected findings is to determine the user behavior, satisfaction and recommendation towards reducing the building energy consumption. Lastly, the fourth expected findings is to figure out the possible initiative that could be taken to retrofit the building and its cost, return of investment payback period.

1.8 Significance of the Study

The research shows an effort and support to a government policy as well as the enhancement by the Ministry of Education in protecting the environment and save the energy resources by reducing the energy consumption in campus building. The monthly and actual building energy intensity provide the comparison on energy requirement as whether the estimated design energy is maximum utilised or somehow there were energy wastage with in proper energy management. The user attitude and satisfaction towards energy consumption also indicates the user awareness on the important of energy efficient building. Besides, the cost analysis provide the forecast of return on investment and payback period if retrofit is decided to be applied in order to gain zero energy balance building. Therefore, this research is significance in reducing the energy consumption, reducing the carbon emission and at the same time save the environment.

1.9 Definition of Terms

Building Energy Intensity	The amount of energy used in producing an output, activity, or service per unit area of the building.
Retrofitting	Renovating or modifying the existing equipment or structure with additional or new components, members or technology.
Zero Energy Building	A building with a net energy consumption of zero over a typical operating year, meaning that the total amount of energy used by the building on typical annual basis is roughly equal to the amount of renewable energy created.

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