Journal of Modern Science and Technology
Vol.2 No.1 February 2014. *Pp.39-48*

Sustainable Energy Management Practices and Its Effect on EEI: A Study on University Buildings

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Energy consumption in commercial buildings contributes greatly towards high energy demand, especially in developed countries. For this reason, energy efficiency in buildings is given increasing attention and included in the energy policy at all levels. However, the complexities of building's energy system make it difficult to gather information on building energy consumption. Many methods have been proposed to measure the energy consumption accurately. The major issues are how to regularly monitor the performance of energy management programs and how to reduce energy usage in a building. This paper focuses on the Energy-Efficiency Index (EEI) as an indicator to track the performance of energy consumption in buildings. A study is conducted at the Engineering Faculties of Universiti Teknologi Malaysia (UTM) using a combination of standard measurements of energy consumption and air-conditioned area from building's databases. Various energy saving management programs were conducted in these faculties since 2010. The results from these programs showed a reduction in EEI and provide opportunities for continuous energy saving practices.

Keywords: Energy Efficiency Index, Energy Consumption, Sustainable Energy, Energy Efficiency

1. Introduction

Recently, there has been a growing concern about energy use in commercial buildings with increasing energy demand and high electricity bill. The United Nations Environment Programme (UNEP) noted that 30%-40% of the world's energy is consumed in buildings (The UNEP website). Since the building sector accumulates approximately a third of the final energy consumption González et al. (2011) , the continuous use of energy will exhaust–energy resources sooner or later. This scenario has in fact led to harmful consequences towards environmental degradation, contributing an irreversible climate change, higher CO_2 emissions, low quality of life and critical health problems due to pollution. Recognizing the impact of environmental degradation, many organizations have developed various regulation and policies to achieve energy efficiency so that they can reduce energy consumption and gas emissions. The European Energy Performance Buildings Directive (EPBD) is one of the policies which aims at promoting energy efficiency in buildings. In Malaysia, 90% of energy consumed is in the form of electricity (Aziz et al., 2012).

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Acknowledgements: This work was supported by Ministry of Higher Education (MOHE), Malaysia and Universiti Teknologi Malaysia (UTM) through the Research University Grant (GUP) vot 00G18.

The commercial building contributes approximately 32% of total energy consumption (Moghimi, 2011). Rapid development in the country results in increased number of buildings as well as energy demand. For efficient use of energy, long term programs towards saving energy are introduced such as the Malaysian standard MS 1525:2007, Code of Practice on Energy Efficiency and use of Renewable Energy for Non- residential Buildings which has been implemented (Sukri et al., 2012). This code of practice aims to reduce energy consumption in buildings by emphasizing energy efficiency from the point of view engineering, architectural, landscaping and site planning for the design of buildings (Ahmed, 2010).

Since university buildings are also high consumers of energy in the category of commercial buildings, many public universities in Malaysia have initiated energy management programs to materialize the call for better use of energy. The program is in line with the efforts of both The Malaysian Ministry of Higher Education (MOHE) and The Malaysian Ministry of Education (MOE) urging all education centres to save energy (Sukri et al. 2012; Wai 2011). This initiative is important because in general, all universities have large build up areas, comprehensive facilities as well as large numbers of building users.

This paper presents the results of implementing various sustainable energy management program measured through the performance of the building's Energy Efficiency Index (EEI). This index is an indicator to measure the pattern of energy consumption in the buildings and used to monitor the improvement in energy efficiency. A study has been carried out on the Engineering Faculties of Universiti Teknologi Malaysia (UTM) where the results and methodologies are presented in the following sections.

The content of this paper is organized according to four major sections. Section 2 provides the literature review on Energy Efficiency Index (EEI) and sustainable energy management key practices. Section 3 gives an outline of the methodology used for the determination of the EEI. Section 4 presents the results and discussion on energy saving strategies and the EEI in UTM and in the various Engineering Faculties. The last section presents the conclusion and includes suggestions for future work.

2. Literature Review

2.1 Energy Efficiency Index

The most commonly used index for comparing energy use in buildings is the Energy Efficiency Index (EEI). This index is usually expressed in kWh/m^2/year which measures the total energy used in a building for one year in kilowatts hours divided by the air-conditioned area of the building in square meters. The air-conditioned area is used as the normalizing factor for comparing buildings. Energy audits that was carried out by Pusat Tenaga Malaysia (PTM) showed the EEI for Malaysian buildings is in the range of 200-250 kWh/m^2/year (Aun, 2008). Meanwhile, research paper done by Aziz et al. (2012) found that the average EEI for Malaysian buildings is 269kWh/m^2/year.

For a building, EEI is a significant tool that acts as a Key Performance Indicator (KPI) to track the performance of energy consumption in a building. This index aims to produce a quantitative energy efficiency metric, based on actual measurements or accurate forecasting of energy consumption (González et al., 2011). EEI also provides the baseline for organization to monitor energy consumption. Baseline energy information is the first step for managing energy in a building (Moghimi, 2011). From this baseline data, an organization will be able to track the energy performance as well as to plan for energy saving targets.

2.2 Sustainable Energy Management Key Practices

Energy management key practices play a major role in achieving energy sustainability. The concept of sustainability has been widely spread to all sectors because it is beneficial towards energy efficiency. Sustainable energy management can be viewed as the process of managing the energy consumption in the organization to assure that energy has been efficiently consumed. The sustainability practices allow consumer to have the benefits of a social infrastructure without limited earth's resources and degrading environment in future. Nigim et al. (2009) included the efficient use of various replenishable and non-replenishable energy resources while severely limiting the ecological footprint in the definition of sustainable energy. Secure sustainable energy need to fulfil two postulates. Firstly, all energy must come from sustainably managed renewable sources and secondly, energy must be distributed and used with highest efficiency. However, the successful implementation of sustainable energy management key practices in the organization will depend on the commitment and cooperation at all management levels.

For the establishment of a sustainable energy, Mohammed et al. (2011) suggested five strategies to optimize energy use in the building. This strategies involves the role of producers building materials , builder, designers, profesional institutions, and the role of governments. To enhance this sustainability, research and education will be a fundamental tools in the most efficient way possible (Denny et al., 2008) . Wai (2011) suggested 47 key practices on how to manage energy in a university. All these key practices were grouped into three major phases: "Planning", "Implementing", and "Monitoring and Evaluation". According to Gorp (2004) energy saving will be able to be maintained over time by consistently implementing energy management practices and adopting recognized measurement as well as verification procedures. The key point to achieve sustainable energy management on campus is by ensuring that each building in the campus improves energy efficiency and are environmental-friendly building.

As awareness on energy saving practices gains momentum, many public universities have taken steps to initiate energy saving programs. Since 2010, UTM has responded to the government's call to save energy by launching the "Go Green Campaign" and "Sustainability Campus Campaign". A study carried out by Saengsuwan et al. (2010) showed that energy consumption in the university can be reduced up to 5 % through conservative sustainable energy concepts such as 'green university' and 'green energy approach'. Three sustainable energy management practices recommended by Mohammed et al. (2011) involve the replacement of incandescent light bulbs with fluorescent lamps, implementation of district heating schemes, and the provision of incentives for solar water heaters. Modern management practices highlight that the strategic approach towards sustainable

energy management stressed the importance of setting goals and tracking performance followed by communicating the results to energy users (Gorp, 2004).

3. Methodology

This section explains the energy management program carried out in UTM, energy audits conducted and the approach used to calculate the Energy Efficiency Index (EEI).

3.1 Energy Management Program

There are several energy saving strategies conducted in UTM which are easy to be implemented and require low investment. Some of the projects that were carried out included projects under the RMK9 project, Off-Peak Tariff Rider (OPTR) discount, energy efficient lighting retrofit, energy awareness campaign program, energy consumption monitoring system using an Electrical Billing Management System (EMBS) and installation of energy-efficient air-conditioning system.

3.2 Facilities Audited

The main key to control energy consumption and cost is by understanding 'when' and 'where' energy is consumed within facilities. The audited facilities in the case study are the Engineering Faculties in UTM. UTM consists of 14 faculties which are divided into two categories: engineering faculties and non-engineering faculties. Out of 14 faculties, there are 9 engineering faculties. All the engineering faculties were audited because their buildings are amongst the highest in terms of energy consumption as compared to the non-engineering faculties. The engineering faculties are listed in Table 1.

Table 1: Name of Audited Faculties

Nos	Name of Faculties
1	Faculty of Mechanical Engineering
2	Faculty of Geoinformation & Real Estate
3	Faculty of Bioscience & Medical Engineering
4	Faculty of Chemical Engineering
5	Faculty of Electrical Engineering
6	Faculty of Architecture
7	Faculty of Civil Engineering
8	Faculty of Petroleum & Renewable Energy
9	Faculty of Biomedical Engineering & Health Science

3.3 Energy Audit

Energy audit is a practical and systematic inspection of energy use in a system or organization. It is also used to identify the required data and ensures that the data collected are reliable. Important data collected during an audit includes the air-conditioned area of the building and energy consumption in the building. The energy consumption data for the buildings audited in the study were collected for lighting, air-

conditioning, computers, printers as well as equipment in the laboratories. The data were then verified by the relevant personnel from the asset and management office.

3.4 EEI Determination

Energy Efficiency Index or EEI is the key performance indicator (KPI) used to track the performance of energy consumption in a building. EEI can be expressed by the following equation:

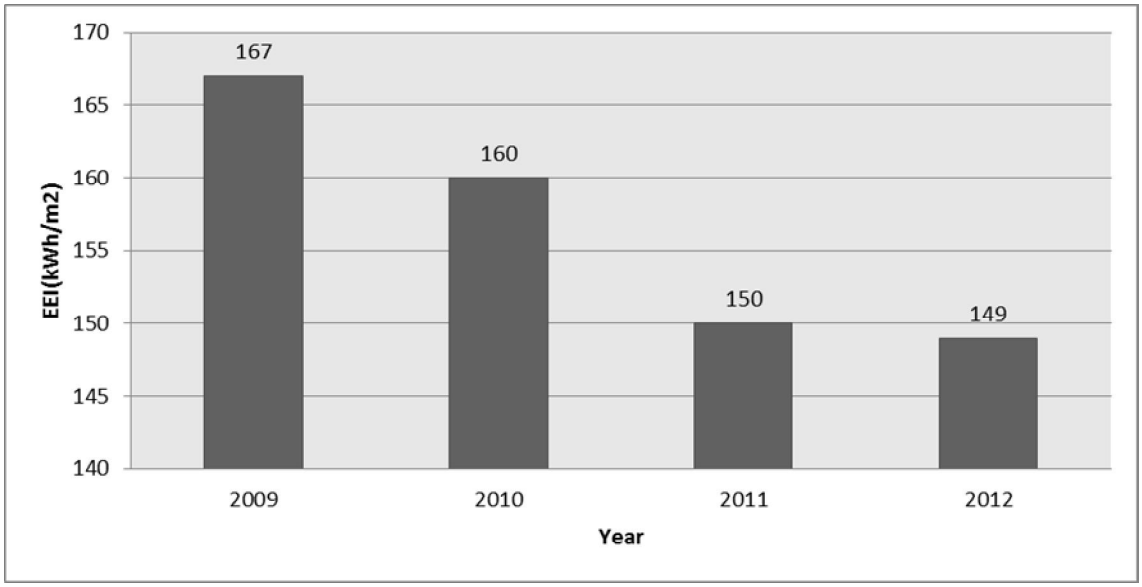
$$EEI = \frac{kWh}{m^2} \quad (1)$$

Where kWh is the energy input (energy consumption) and m^2 is the air-conditioned area of the building (factor related to the energy using component). The unit of EEI is expressed in kWh/m^2.

4. Results and Discussion

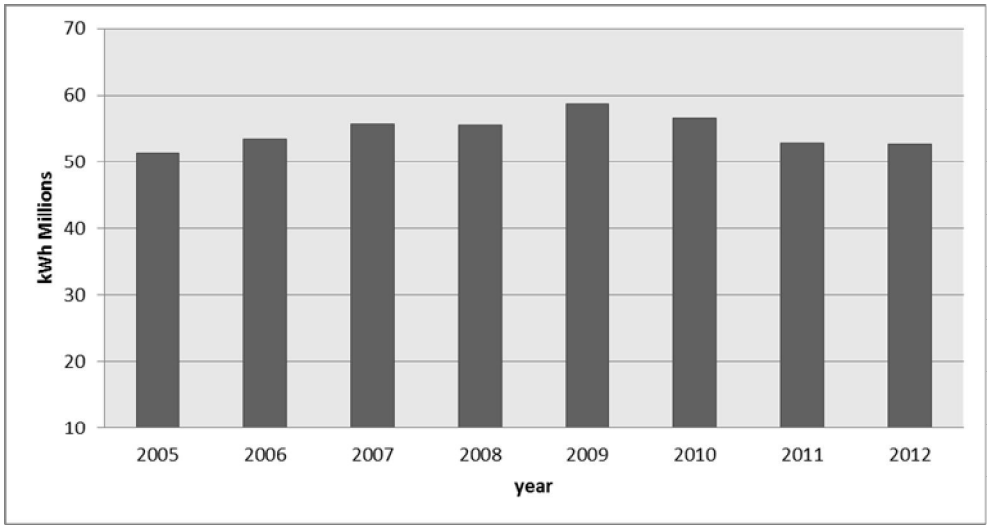
UTM has established an Energy Management Program throughout the whole university involving faculties, colleges and offices since 2011. UTM's involvement in this program has enabled it to achieve the Energy Management Gold Standard Certification (One Gold Star) in 2011 under the ASEAN Energy Management Scheme (AEMAS). The eligibility for this certification requires an institution to show improvement of their Energy Efficiency Index as well as able to manage their energy based on ISO 500001 standard (Sukri et al., 2012). Figure 1 shows the performance of Energy Efficiency Index for UTM from 2009 until 2012. It can be seen that the EEI has shown a decreasing trend due to the initiative taken in the year 2011. UTM also embarked on “A One-Stop Centre for Sustainable Energy Management’ project which led UTM to be a winner of the ASEAN Energy Award 2012 for the ‘Large Building Category’. The award was given by the ASEAN Centre for Energy (ACE) as a recognition to institution/organization for outstanding efforts in energy management.

Figure 1: Energy Efficiency Index in UTM for 2009-2012



UTM is among the organizations with the largest energy consumption within the state of Johor. UTM's annual electricity bill for 2009 is approximately RM18.99 million. As shown in Figure 2, the annual electrical usage trend in 2009 is the highest due to the increased number of students and also the increased number of buildings within the campus. This scenario is also a reflection of the low awareness of energy saving among staff and students on campus. However, due to the Energy Management Program that was in place beginning 2010, there is a marked reduction in energy consumption.

Figure 2: Electrical Usage Trend in UTM from 2005 To 2012



The following table highlights the energy saving strategies carried out in UTM in order to achieve sustainability. There are four main energy efficiency target areas: Housekeeping, Sustainable Energy Management Tools, Key Focus Energy System, and Awareness. Each energy efficiency target area includes several initiatives to reduce energy consumption.

Table 2: Energy Saving Strategies

Bil	Energy Efficiency Target Area	Initiatives Taken
1	Housekeeping	• Reset operation of centralised Air-Conditioning (AC) System (24°C from 7.30am-4.30pm) • Policy not to use centralised AC during weekend • Continuous monthly/daily/weekend checking on street/building lightings, centralised AC system • Installation of soft starter for AC system
2	Sustainable Energy Management Tools	• Bi-monthly energy management review • Electrical Billing Management System (EBMS) • TNB OPTR 20% discount • TNB street lighting tariff correction • EM practice best practice check-list • EM document sharing • UTM-optimal audit • Carbon Calculator
3	Key Focus Energy System	• Lighting o Lighting Retrofit o Private Financing Initiatives(PFI): LED street lighting retrofit • Air-Conditioning o Private Financing Initiatives(PFI): Installation of VRF AC system • Use of Renewable energy (PFI): o Solar system and wind turbine pilot project
4	Awareness	• Awareness program at faculties, colleges and offices • Energy saving campaign • Yearly workshop on Energy Management Working procedure • Monthly energy management report to University's Management group • Email Group & Facebook

Figure 3: Energy Efficiency Index by Faculty in UTM

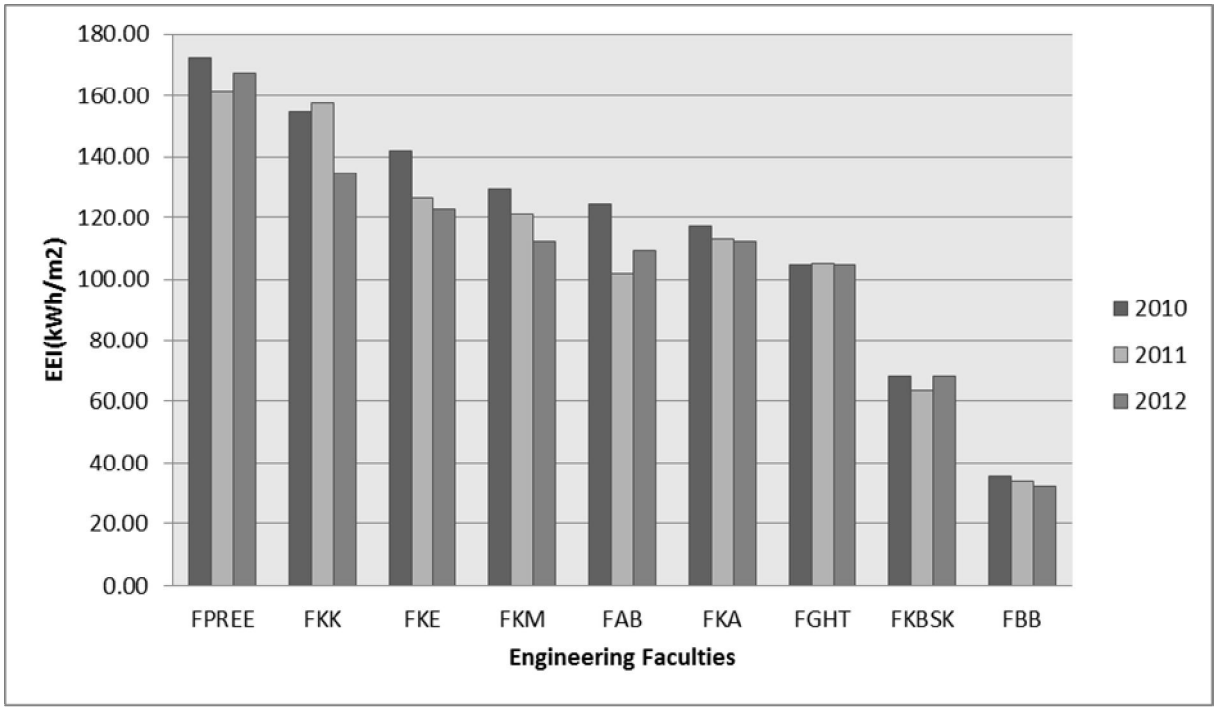


Figure 3 shows the EEI's annual performance for the engineering faculties in UTM for the years 2010-2012. EEI depends on the building's energy consumption and air-conditioned area. Besides, EEI also depends on the activities carried out in each particular block (Sukri et al., 2012). A reduction in a building's EEI with no changes in the floor area and almost similar activities for the period considered indicates that the building is consuming less energy. Most of the faculties show a reduction in EEI for the year of 2011 compared to the year 2010. This achievement is the result of the energy-saving program that was conducted in UTM as shown in Table 2. In 2011, energy efficient lighting retrofit was implemented by replacing T8 fluorescent lamps with T5 fluorescent lamps. A total number of 34318 lamps were replaced. This replacement resulted in a 50% saving of the energy consumption for the lighting involved, and it is estimated that the electricity bill saving will be RM5.2 million in five years. In order to continue the effort to save energy, UTM also replaced older centralized systems with the Variable Refrigerant Flow (VRV) air-conditioning system for six faculty buildings. The volume or flow rate of refrigerant in the VRF system is accurately matched to the required cooling loads thereby saving energy and providing more accurate control. With the installation of the VRF system, the CO_2 reduction is estimated to be 655 tonnes/year and a saving of up to RM2.15 million/year on the electricity bill can be achieved.

5. Conclusion

This paper has presented a study for engineering faculties in UTM. From the analysis of the Energy Efficiency Index (EEI) it can be concluded that:

(a) There is significant improvement in the energy performance by implementing energy management strategies. The adoption of RMK9 project, Off-Peak Tariff Rider (OPTR) discount, energy efficient lighting retrofit, energy awareness

campaign program, energy consumption monitoring system using an Electrical Billing Management System (EMBS) and installation of energy-efficient air-conditioning system significantly reduced UTM's overall energy consumption, EEI and electricity cost even though there was an increase in the number of buildings and students. UTM's annual EEI is also well below the average EEI for Malaysian Buildings (269kWh/m^2).

(b) Energy management program conducted in UTM had a great impact on the Energy Efficiency Index with a decrease of 6.88% in 2012. The amount of energy saved in 2012 compared to 2010 was 3.9 Million kWh, which is equivalent to RM3.3 Million.

(c) Implementation of energy sustainability initiatives will bring enormous savings to an organization such as a public university.

Each implemented energy saving initiative had contributed greatly towards achieving a sustainable energy management program. Further research work is suggested to be carried out to accurately quantify the impact of each initiative. To further enhance energy efficiency practices within university buildings, it is also suggested to benchmark the EEI for university buildings. It is envisaged that the continuation of these initiatives and extension of the sustainable energy management program to the whole campus would result in tremendous energy savings University-wide.

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