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Building Energy Intensity Measurement for Potential Retrofitting of Zero Energy Building in Higher Learning Institution

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ABSTRACT

Energy is currently world debate and being a prominent issue especially in industrial, transportation, residential and service sector. Service sector that includes all commercial and public buildings are also being the major contributor of global energy consumption. Higher Learning Institution (HLI) are among public buildings that the energy demand has become a critical issue, in which HLI need to spend a considerable high amount of money annually for electricity consumption. This energy issue somehow can be improved by implementing the retrofit to existing building which employed energy efficient technology, where it involves modifications using sustainable building criteria. This paper highlighted various options for building retrofitting which from lean steps, green technology and clean energy. M50 building in Faculty of Civil Engineering Universiti Teknologi Malaysia (UTM) was chosen as a case study and in situ energy audit of Building Energy Intensity (BEI) was conducted by identifying the types of equipment and machinery used in the building together with its period of operations and their power usage under typical operation. The outcome of the study proposed the retrofit strategies that are suitable to be implemented towards zero energy building. It is a cornerstone of reducing the energy usage with sustainability efforts together with economic stimulus packages.

Keywords: *Building Energy Intensity, Retrofitting, Campus Building, Zero Energy Building, Energy Consumption, Energy Efficiency.*

1. INTRODUCTION

The effort to boost the energy efficiency of the commercial, residential and public building is always become priority as it is opportunities to save money, enhance air quality while at the same time improving indoor quality, as well as reducing climate pollution. Thus, several initiatives and strategies for building retrofits in implementing the energy efficiency are emerging because simultaneously, it meets the environmental protection, economic development and social goals (Foy & Rogers, 2008). As building is known among the highest electricity consumption in which it uses 30% of world energy, it consequently becomes a favoured target for an energy efficiency initiative towards the achievement of zero net building energy (Laponche, 2012). This paper report an achievement of partial objective of PhD study with a title "Holistic Initiatives for Decision Making in Retrofitting of Zero Energy Building in Higher Learning Institution".

In campus building, energy efficiency has become a critical issue because the electricity usage has always rapidly increased and the university needs to spend a considerable amount of money annually to support the electricity consumption (Jomoah et. al, 2013). It has been estimated that in a smaller scale of Higher Learning Institution (HLI) which has a population of 31,302 students able to produce 234,765tCo2 through the usage of electricity. Therefore, it also shows that institution is among the major contributor to greenhouse gas emissions (Syed Hussein et.al, 2013).

There are several reasons to explain why energy conservation in HLI is essential. Firstly, HLI has a large number of populations compared with other industries until HLI have been regarded as 'small cities'. They have large size of building areas and facilities ranging from classroom, hall, office, library, laboratories and others where most of the energy was embedded in these facilities such as lighting and air-conditioning system. Besides, in HLI also there are various complex activities taking place such as teaching and research which also required a large amount of energy usage. Therefore, energy conservation is significant in majority of higher educational institution to considerably reduce the energy consumption by an effective choice and technical measures (Alshuwaikat and Abubakar, 2008). Table 1 shows the list of electricity consumption data in Ringgit Malaysia (RM) in nineteen (19) Malaysian HLI, from year 2010 to 2014. Most of the Universities are having increments of their electricity cost which they need to spend a considerable high amount of money annually for electricity consumption.

Table 1: Electricity Cost in nineteen Malaysian HLI
Source: (Jawatankuasa Tindakan Pembangunan Kerajaan, 2014)

BIL	INSTITUTION	YEAR				
		2010 (RM)	2011 (RM)	2012 (RM)	2013 (RM)	2014 (RM)
1	Universiti Putra Malaysia	-	2,132,808.00	2,433,377.00	2,828,215.00	2,936,007.00
2	Universiti Malaya	2,036,323.52	2,148,498.52	2,358,745.45	2,496,145.94	2,959,396.99
3	Pusat Perubatan Universiti Malaya	1,423,030	1,505,396	1,897,514	1,943,141	2,125,099
4	Universiti Kebangsaan Malaysia	1,506,579	1,505,649	1,671,598	1,657,814	1,929,734
5	Universiti Sains Malaysia	1,240,396.25	1,240,425.14	1,305,754.10	1,276,913.58	1,501,083.64
6	Universiti Teknologi Malaysia	1,522,006	1,516,239	1,473,429	1,461,132	1,669,732
7	Universiti Teknologi Mara	2,054,349	2,008,786	2,132,465	2,054,028	2,406,107
8	Universiti Islam Agama Malaysia	1,646,283	1,687,519	1,860,64	1,859,010	2,048,251
9	Universiti Utara Malaysia	1,303,745	1,303,492	1,473,550	1,480,825	1,603,472
10	Universiti Malaysia Sarawak	929,942	1,095,462	1,171,045	1,160,926	1,194,003
11	Universiti Malaysia Sabah	-	1,265,272	1,308,009	1,510,529	1,571,260
12	Universiti Pendidikan Sultan Idris	441,089	472,400	830,601	856,459	939,592
13	Universiti Malaysia Pahang	494,741	569,656	750,689	724,115	1,023,198
14	Universiti Malaysia Perlis	377,016	436,168	616,080	712,525	881,675
15	Universiti Tun Hussein Onn Malaysia	584,848	620,385	986,341	1,028,652	1,105,853
16	Universiti Teknikal Melaka Malaysia	-	545,544	569,652	568,850	632,339
17	Universiti Sains Islam Malaysia	-	487,348	581,540	639,547	764,743
18	Universiti Malaysia Terengganu	398,099	433,982	548,356	593,221	719,051
19	Universiti Malaysia Kelantan	-	-	119,424	124,368	192,538

It is possible that there are huge opportunities of energy savings could be done in HLI buildings, by identifying the potential for building retrofitting and their effectiveness for energy reduction. It is important to develop the retrofitting technology and initiatives as it (i) enhance and culture the response to energy conservation, (ii) to improve the energy efficiency, (iii) to aware the optimum building intensity, and (iv) to providing better building performance. Besides, by identifying the initiatives of building to be retrofitted, it is useful for the building management to do further planning and actions in responsive for a zero energy building.

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2. RESEARCH METHODS

This paper employed exploration research and in-situ measurement of all pertaining information through access to the published journals, books, articles, and other sources in order to get an insight and overview of the study. A case study building in Universiti Teknologi Malaysia (UTM), named M50 was selected for the exploration and in-situ measurement. This M50 was chosen due to it have some criteria that response to energy efficient building. The exploration of the actual data started with an energy record review by collection of monthly electricity billing. This showed the pattern of monthly energy used in operation of the case study building. In-situ measurement or energy audit of Building Energy Intensity (BEI) also has been conducted, whereby it indicating energy peak during the semester session and energy low peak during the semester break. This consideration is due to the case study building is operating during two periods which different demand of energy consumption and affecting the value BEI. In-situ energy audit was executed by identifying the types of equipment, machineries and electrical appliances used in the buildings and to survey the building's energy consuming equipment. This included the lighting, air-conditioning, refrigerator and etc. The period of operation (hours) under typical operation also been observed and their power usage was recorded by using the wattmeter. All the data collected used for the basis in determining the actual BEI. Lastly, with the identification of actual BEI, the higher energy usage between the equipment, machinery and electrical appliances used in the building was identified. This result lead to determine the possible retrofit initiative that could be taken to reduce building energy consumption. The list of retrofit technologies and initiatives was obtained from critical analysis from relevant sources from previous and current research energy efficient buildings.

2.1 Building Energy Intensity Measurement

In order to measure the actual BEI the gross floor area, wattage and time usage of the equipment, machineries and electrical appliances in the building were determined and classified according to their room. The time usages were divided into two categories which are scheduled and unscheduled due to their different time usage. Scheduled is defined as the time which has designated such as laboratories and classrooms.

While unscheduled is described as unspecific time usage such as academic staff rooms by estimating into eight categories which are 5, 10, 20, 30, 40, 60, 80 and 100% of utilization. The formula of BEI is as below:

$$Building\ Energy\ Index\ (BEI) = \frac{*Total\ Energy\ Usage}{Total\ Net\ Groos\ Floor\ Area} kWh/m2/year$$

*Total Energy Usage = Power of each equipment and machinery x hour usage

3.0 LITERATURE REVIEW

3.1 Building Energy Intensity

Energy intensity is defined as the ratio of total building energy usage (kWh) per year to the building area (m^2) (Moghimi et.al, 2013). While, according to U.S Department of energy (2015), energy intensity is the amount of energy used to produce an output or activity and it's expressed as energy per unit of output or activity. BEI is the determination of building energy consumption and commonly used to measure the building energy performance. BEI involve in considering its energy consumption together with its building size to assist whether the building is over consume or under consume of energy (Yahya et.al, 2014).

3.2 Retrofitting in Higher Learning Institution

Retrofitting is defined as upgrading the existing building that is wholly or partially occupied to improve the environmental and energy performance; improve the building quality, reducing the water usage, improve the comfortability and quality of building space such as noise, air quality and natural light which all done to provide the owner financially benefit (Campbell, 2009). Retrofitting is the processes of replacing and upgrading the system from old building with new energy saving technology. Retrofit is also known as operational upgrade or physical upgrade of building's energy consuming equipment (Fulton, 2012). According to Zakaria (2012), retrofitting is the process of renovate or refurbish of an existing building and assists to bring the largest potential of energy savings by incorporating the energy efficiency measures and renewable energy technologies.

The development of commercial building projects are currently globally emerging which indirectly has contributed to the significant impact to the environment and energy demand. Commercial building has its own uniqueness application and therefore the energy usage is often exceeding the required load in order to operate the building. In Malaysia, the development of country also led to the growth of commercial building such as HLI in order to fulfill the accommodation and growing demand of the local and international students. Nowadays there are at least one public and one private institution in each state. Therefore, this rapid development of the HLI has made all the Ministry of Higher Education Malaysia and the Ministry of Education to encourage all the institution to get involve with the sustainability effort as to enhance for energy savings. This encouragement also is to support the effort from the Ministry of Energy, Green Technology and Water in responds to achieve for sustainability and energy saving in all building (Sukri, 2012).

Campus sustainability has been globally concern especially by the policy makers and planners because most of them aware that activities and operations involve in campus usually have a significant impact on energy usage. In addition, the governments, environmental protection agencies, university's stakeholders, NGOs and sustainability movement are also encourage in cooperating and fully committing towards the effort of sustainability (Alshuwaikat and Abubakar, 2008). Furthermore, Lo (2013) stated it is important to focus on sustainability in HLI by implementing the energy conservation because HLI known as among the major energy consumers, involve in higher energy cost, highly related with climate changes and always affected by the shortage of non-renewable energy resources. Therefore, energy conservation is an

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essential ingredient in HLI in order to optimize the energy use and to yield for the monetary savings. Basically, the universities can contribute and achieve the sustainable development in several ways and one of them is by incorporating a good technology and practices (Silva et.al, 2013).

3.3 Retrofitting Technology

There are three approaches of retrofit technologies which can be implemented as an energy conservation measures which called as Lean energy, Green technology and Clean energy. Lean energy is a good design principle by using the current technology (Chee Yue, 2014).

According Tymkow et. al (2013) for a building to be lean, it means the building need to use less energy and being energy efficient with the purpose of reducing the current energy demand. The key features of passive (lean) design can include the consideration of building form, orientation, colour, building envelope, shading, massing, insulation, landscaping, and selecting the right materials (Syed Fadzil & Byrd, 2012).

Meanwhile, green technology is defined as applying the low carbon and neutral technologies by supplying the energy efficiently (Chee Yue, 2014). Green technology is an innovation with the purpose to protect the environment and minimize the energy consumption by adopting the new technology to the existing technology (Puvanasvaran et.al, 2012). According to Hassan (2014), green technology is the development and application of products, equipment and systems which used to conserve the natural environment and resources.

Lastly, clean energy is described as using renewable technologies to offer for a greater reduction of energy (Chee Yue, 2014). According to Autodesk Sustainability Workshop (2011), after the utilization of green technology, clean energy is the best strategies by looking and considering the clean sources or renewable sources in order to fulfill the building energy demand. There are several types of clean energy which can be incorporated such as solar photovoltaics, solar hot water, wind power, clean grid power and etc. Besides, Green Cross Australia (2015) stated that the power stations in most countries used of fossil fuels such as coal and oil to generate the electricity. The process of making the electricity caused a lot of greenhouse gases and thus making the atmosphere warm. With the availability of clean energy sources such as sun, wind, waves and water, it can be used as an alternative to supply more clean energy in a building or industry which then brings the biggest impact in reducing the greenhouse gas emissions.

3.4 Zero Energy Building

Zero energy building is described as a target of energy efficient building in order to develop a sustainable future in achieving a good value in social, environmental and economic. Zero energy does not limit in offering the energy reduction but also concern in giving a good environmental quality, occupant's health and well-being. Besides, zero energy building also offers a new standard to achieve for high-performing building, good market value, lowest life-cycle cost and enhance the occupant's quality of life (Hootman, 2013). In addition, zero energy building concepts is not limited for a new construction only but nowadays has been considered to implement for a retrofit project. It was utilize for existing building as an approach to bring in the most cost-effective energy, minimizing energy cost and maximizing the energy savings (Krarti, 2012).

Zero Energy Building is a building that generating and consuming of clean energy as the building energy consumption and emission are offset by renewable energy (Carmicheal and Managan, 2013). Zero Energy building also is described as a building which consume energy without using any fossil fuels and the energy is obtain directly from renewable energy sources such as solar (Laustsen, 2008). Besides, Hyde et.al (2012) described that zero energy is a building which has zero net energy consumption and zero emission of carbon annually. In achieve a good strategy of zero energy building, increasing the energy efficiency and reducing the energy demand is required by adopting passive heating and cooling system and then using renewable energy sources to increase the energy supply such as solar thermal and solar electrical system.

Zero Energy Building should be adopted as a part in developing and improving the current built environment because all building including the existing has the potential to be integrate as zero energy. It was also known as an approach which offers a powerful synergy towards the development of built environment (Hootman, 2013).

4.0 CASE STUDY FINDINGS

4.1 The Monthly Energy Consumption of M50 Building

Table 2 shows the M50 building monthly power consumption and the electricity cost starting the day of the building operated until June 2014. By using the data, the BEI value was calculated by dividing the power consumption of each month with the building gross floor area, 3981.98 m2. The result is as shown in Table 3. While, in Figure 1 illustrates the fluctuations of the monthly BEI value where the value was influenced by the intensity of the energy used throughout the whole semester. Starting from November 2011 until April 2012, the BEI is increasing because during that period the building is in the process of opening and therefore much electrical energy being used to install the equipment, instrument, electrical appliances and facilities. Furthermore, the number of lecturers occupying the rooms was also increasing during this period whereby they move from old building to this new building of M50. Besides, the highest BEI is during semester 1 2012/2013 (October 2012) which was 6.33 kWh/m2 with the electricity bill RM 7860.84. It is because the semester was actively running as usual where the building was filled with teaching, learning and laboratory activities and therefore most of the spaces are occupied. While, the lowest was 2.79 kWh/m2 which it was during the semester break (January 2014) with the electricity bill cost RM4059.17. However, during semester break such as in July 2012, August 2012 and July 2013, the BEI value were slightly higher which is 4.77, 4.20 and 4.37 kWh/m2 because the building was occupied by the part time and postgraduate research students who executing their laboratory project. Therefore, this activity caused the intensity of energy usage in demand even though during semester breaks.

Table 2: Monthly power consumption and electrical bill of M50 building (Recorded from: Masilah, 2014)

Floor Area (m²)	**Month**	**Total Unit (kWh)**	**Total Cost (RM)**
3981.98	Jun-14	21,845	6815.64
	May-14	20,318	6339.22
	Apr-14	21,292	6643.1
	Mar-14	20,263	6322.06
	Feb-14	16,568	5169.22
	Jan-14	11,121	4059.17
	Dec-13	13,684	4269.41
	Nov-13	19,358	6039.7
	Oct-13	22,563	7039.66
	Sep-13	14,556	4541.47
	Aug-13	11,636	3630.43
	Jul-13	17,406	5430.67
	Jun-13	18,450	5756.4
	May-13	22,521	7026.55
	Apr-13	24,986	7795.63
	Mar-13	22,064	6883.97
	Feb-13	14,035	4378.92
	Jan-13	18,035	5626.92
	Dec-12	17,936	5596.03
	Nov-12	16,899	5272.49
	Oct-12	25,195	7860.84
	Sep-12	18,070	5637.84
	Aug-12	16,737	5221.94
	Jul-12	18,997	5927.06
	Jun-12	18,116	5652.19
	May-12	18,467	5761.7
	Apr-12	14,974	4671.89
	Mar-12	8,779	2739.05
	Feb-12	9,010	2811.12
	Jan-12	8,887	2772.74
	Dec-11	7,044	2197.73
	Nov-11	2,952	921.02
	Oct-11	0	0

Table 3: Monthly Building Energy Intensity of M50

Month	Academic Schedule	BEI (kWh/m²)
Oct-11	Semester 1 2011/2012	Not Operated
Nov-11		0.74
Dec-11		1.77
Jan-12		2.23
Feb-12	Semester Break	2.26
Mar-12	Semester 2 2011/2012	2.2
Apr-12		3.76
May-12		4.64
Jun-12		4.55
Jul-12	Semester Break	4.77
Aug-12		4.2
Sep-12	Semester 1 2012/2013	4.54
Oct-12		6.33
Nov-12		4.24
Dec-12		4.5
Jan-13		4.53
Feb-13	Semester Break	3.52
Mar-13	Semester 2 2012/2013	5.54
Apr-13		6.27
May-13		5.66
Jun-13		4.63
Jul-13	Semester Break	4.37
Aug-13		2.92
Sep-13	Semester 1 2013/2014	3.66
Oct-13		5.67
Nov-13		4.86
Dec-13		3.44
Jan-14	Semester Break	2.79
Feb-14	Semester 2 2013/2014	4.16
Mar-14		5.09
Apr-14		5.35
May-14		5.1
Jun-14		5.49

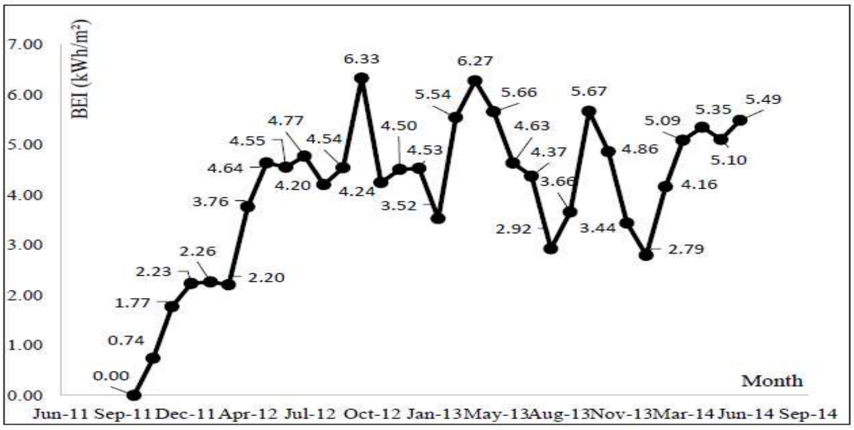

Figure 1: The monthly BEI pattern at M50 building from October 2011 to June 2014

4.2 Actual Building Energy Intensity of M50 Building

The measurement of actual BEI is crucial in determining the energy that is potentially to be reduced. Besides, the identification of BEI assist in the decision to retrofit initiatives that need to be taken based on the equipment, machineries and electrical appliances that give higher contribution to the energy usage. The actual BEI were identified by measuring the power used by each electrical appliance, hour of operation and the gross floor area of the room. The calculation was divided into scheduled and unscheduled room.

The scheduled BEI is the hour usage of the equipment, machineries and electrical appliances which based on the room schedule that has been provided by the management of the faculty such as laboratories and Lecture rooms. Based on the observation and interview, the maximum hour usage of the equipment and machineries in the laboratory for one day is about 1hour. Besides, there are also some electrical appliances which are being fully occupied during the working hours (8 hours per day) such as technician rooms in Structure Laboratory and Casting Laboratory because there are two technicians has been assigned to manage the laboratory. While, in other laboratories, the technician has only been present during the laboratory sessions as per scheduled provided. Therefore, based on the energy audit conducted, the air conditioning is the most energy consuming in the building with the highest BEI value 2147.04 kWh/m2 per month which located in environmental laboratory. It is because the air conditioning has consumed 40 hours per week. Another equipment which consumes the highest BEI value is lighting (fluorescent lamps) which is 362.88 kWh/m2 per month with 10 hours usage per week, located in Hydraulic and Hydrology Laboratory. While, refrigerator is the third largest energy consumes with the BEI value 146.83 kWh/m2 per month. The refrigerator is used for 40 hours per week which located at the transportation laboratory.

Besides, there are two types of lecture room provided in the building, namely as Lecture Room 1 and Lecture Room 2 located on the second floor which both has the same floor area, 60m2. Thus, the energy audit conducted has found that air-conditioning is the most energy consuming in both rooms with the BEI value 477.12 kWh/m2 per month with 40 hours of usage per week. Meanwhile, lighting (fluorescent lamps) has consumes 57.60 kWh/m2 with the total usage of 40 hours per week.

The overall BEI value under the category for scheduled room is as follows:

$$\text{Scheduled BEI} = \frac{\text{Total kWh/month}}{\text{Total Net Floor Area}}$$

$$= \frac{9627.73}{2969.7}$$

$$= 3.24 \text{ kWh/m2/month}$$

Meanwhile, unscheduled BEI is described as an unspecific schedule of time usage for the equipment, machineries and electrical appliances. The building categorized under this unscheduled BEI is corridor, lobby and other rooms (seminar, viva, toilets, control, mdf, prayer and academic staff rooms). The highest BEI value found under the unscheduled room is in the academic staff rooms on the second floor of the building which consumes the air conditioning at 4114.24 kWh/m2 per month with 40 hours usage per week. Also, at the third floor of the building, academic staff rooms, has found as among the highest consuming of air conditioning with the BEI value 1609.92 kWh/m2 per month with 40 hours usage per week. Other than that, lighting (fluorescent lamps) also has been identified as the most energy consuming in the academic staff rooms with the BEI value 529.92 kWh/m2 and 207.36 kWh/m2 with 40 hours usage per week, which both located on the second floor and third floor of the building.

The overall BEI value under the category of unscheduled room is as follows:

$$\text{Unscheduled BEI} = \frac{\text{Total kWh/month}}{\text{Total Net Floor Area}}$$

$$= \frac{11254.19}{1504.84}$$

$$= 7.48 \text{ kWh/m2/month}$$

At first, the hour usage for all the spaces under unscheduled category was assumed being used for 8 hours per working day. While, for mdf and control room, it was assumed being operated 24 hours per day. However, after the determination of the overall unscheduled BEI, it was then categorized based on its percent of utilization vary from 5, 10, 20, 30, 40, 60, 80 and 100%. Then, the actual BEI value for M50 building was determined by total up the scheduled and unscheduled BEI. Table 4 shows the Building Energy Intensity (BEI) value of M50 which portrays its utilization from 5, 10, 20, 30, 40, 60, 80 and 100%. Based on the result, the actual BEI values were in the range of 3.61 to 10.72 kWh/m2

Table 4: Actual Building Energy Intensity (BEI) M50

*Scheduled BEI (kWh/m2)	**Unscheduled BEI (kWh/m2)	Percentage of Utilization	Unscheduled BEI based on its Utilization (kWh/m2)	Actual BEI (kWh/m2)
3.24	7.48	5%	0.37	3.61
		10%	0.75	3.99
		20%	1.50	4.74
		30%	2.24	5.48
		40%	2.99	6.23
		60%	4.49	7.73
		80%	5.98	9.22
		100%	7.48	10.72

*Laboratories, Lecture rooms
** Corridor, lobby and other rooms (seminar, viva, toilets, control, mdf, prayer and academic staff rooms)

Example calculation of actual BEI (for 40% utilization):

$$= 3.24 + 40\% \, (7.48)$$
$$= 3.24 + 2.99$$
$$= 6.23 \text{ kWh/m}^2\text{/month}$$

4.3 Comparison between Monthly and Actual Building Energy Intensity (BEI)

After the determination actual BEI, the building energy utilization was identified by comparing the highest monthly BEI with the closer percent of utilization on actual BEI. The purpose was to determine the energy that need to be reduced at the time the building in highest utilization. Figure 2 illustrated the graph comparison between monthly and actual BEI of M50 building. The fluctuation of the building energy utilization is caused by the inconsistency presence of the occupant in the building and also due to the different schedule of energy usage. For example, every lecturer has a different schedule as they have taught session, meeting, talk or program to be attend and thus some of the lecturers will only spend some time of the working hour in their room.

From the comparison, it can be seen that the highest actual BEI were in the range of 40% energy utilization, 6.23 kWh/m2 and the monthly BEI is 6.33 kWh/m2. The highest energy utilization is only at 40% as the building was only operated during the working hour which is 8 hours per day. However, if the building was being used during the night time such as having a night class, thus it can contribute to the increasing of percentage of building energy utilization in that month. Meanwhile, since the building operated until June 2014, the lowest actual BEI is at 5% of energy utilization which is 3.61 kWh/m2 and the monthly BEI is 3.44 kWh/m2.

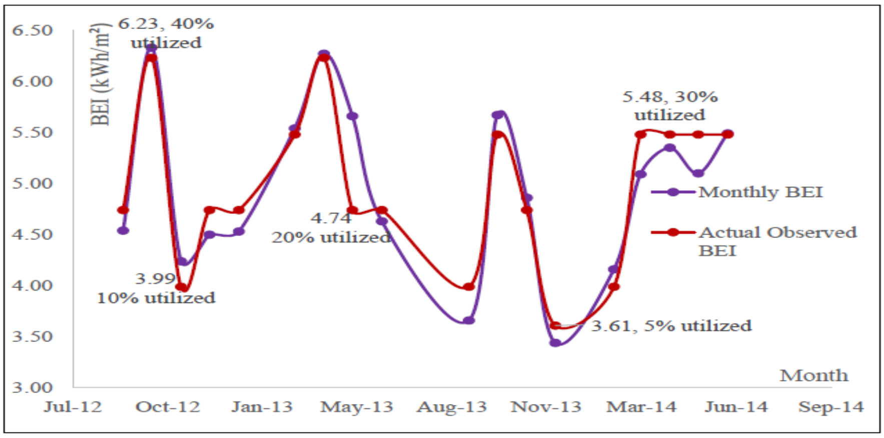

Figure 2: Comparison between monthly and actual Building Energy Intensity (BEI)

5.0 POTENTIAL RETROFITS INITIATIVES TOWARDS ZERO ENERGY BUILDING

In order to suggest for a suitable retrofit technology towards in reducing the current building energy consumption, the identification was made on the electrical appliances which has the highest contribution in BEI value. Based on the data collected, it is found that lighting, air-conditioning and refrigerator used in the laboratory are among the major contributor to high energy. Therefore, in order to improve the current energy usage, the application of retrofit initiatives are focusing on lean energy, green technology and clean energy.

For lean approach, the use of cool breeze can be the most effective solution in solving the issue of high energy usage of air-conditioning. Cool breeze is the use of wind force to provide an adequate air to ventilate the building spaces by having a little or no use of active cooling and HVAC system. In order to gain the satisfaction of cool breeze, window plays an important strategy such as having an operable window to easily allow the wind into the building. Not only that, plantations or vegetation around the building also provide a good breeze flow and diversion into the house (Australian Government, 2013). Other than that, the application of green roof also help to reduce the energy usage of air-conditioning because the application of green roof especially in hot climate helps to lower the temperatures of the building and thus help to cool the building (Ascione et.al, 2013). Green roof is a passive cooling technique function as a shade of the roof surfaces and it block the sunlight from reaching to the underling of the membrane surface. It removes the heat from the air through the process of evapotranspiration. With a green roof, the building can stay cooler and thus the user in the building feel less of heat flows and reduce the air-conditioning temperature (U.S. Environmental Protection Agency's Office of Atmospheric Programs, 2008).

Another lean approach which can be implemented is daylighting which can be the best practice to reduce the usage of lighting. Daylighting is using sun as a source to provide a desirable diffuse natural light, visual comfort and luminous efficacy. The location and apertures are the main strategies in utilizing the natural light, for example having a higher aperture such as a glazing roof. Higher apertures functioning as a 'top lighting' to give much brighter and deep light per unit area. This can include skylights and clerestories (Autodesk Sustainability Workshop, 2011).

For green technology approach, the high energy usage of air-conditioning can be installed with Variable Frequency Drives especially at their component such as pumps or fans. It has the ability to match the speed with the process requirement by controlling the frequency of electric power supplied to the motor. It allows the motor to consume less energy when the load requirements are less than full speed. For a lighting, as the building majority was used fluorescent lamps, it is suggested in upgrading the existing lighting with new efficient lighting such as replacing the T8 electromagnetic ballast with T8 electronic ballast, or converting the old T8 bulbs from T8 18W and 36W down to high performance T8 (HPT8) 17W and 32W and T5 14W and 28W. Not limited to that, occupancy sensor and motion sensor also is believed could help to solve both for lighting and air conditioning issue because it is act as an 'energy monitors'. The lighting and air-conditioning will automatically switch off when the spaces are not being occupied. Besides, an energy saving equipment also could be installed in the centralized chiller system to optimize the compressors from operating at excessive capacity because the chiller will only functioning during the typical 8 hours of the working day. Other than that, for a refrigerator, an initiative that can be taken is the replacement of old and inefficient refrigerator with new models which are much cheaper and required less of energy.

However, in response towards zero energy building, focusing on renewable energy is highly desirable. Zakaria et.al (2012) has investigated the significant criteria to be used in retrofit the existing building in Universiti Teknologi Malaysia (UTM) and it is found that renewable energy technologies such as solar photovoltaic has been the most preferable criteria to be implemented. According to Johari et.al (2012), as the weather condition in Malaysia receives an abundance of sunlight over the year, therefore the integration of solar photovoltaic has the viability in generating the electricity. Solar is known as the sources of renewable energy which is clean and does not emit any of CO_2 emission when the electricity is generated.

In additon, Mohd Pauzi (2014) has also identified on the most preferable retrofitting technology to be installed at the M50 building by obtaining feedback from respondents. From Table 5, it shows that majority of the respondents agrees that solar photovoltaic is the most preferable retrofitting technology that is suitable for the building with the Relative Importance Index (RII) rank reached 0.90.

Table 5: Respondents preferable Retrofitting Technology

Retrofitting Technology	Score	Relative Importance Index (RII)	Ranks
a. Solar Photovoltaic	252	0.90	1
b. Shutter/ Blind Control	215	0.77	2
c. Variable Air Volume (VAV)	213	0.76	3
d. Replace Window with Low Emissivity Glass	195	0.70	4
e. Grass Roof	178	0.64	5
f. Presence Sensor with Lux Control	173	0.62	6
g. Computerized Automation System	166	0.59	7
h. Reflective Roofing	153	0.55	8
i. Peak Load Warning Technology	109	0.39	9
j. Electronic Ballast for Lighting Device	80	0.29	10
k. Demand Limiting Controller (DLC)	75	0.27	11
k. Radiant Floor System	74	0.26	12
l. Push Button with Thermostat	67	0.24	13
m. Control Cabling in UPVC Conduit	65	0.23	14

6.0 CONCLUSION

In this study, the results have proven that M50 building Faculty of Civil Engineering, Universiti Teknologi Malaysia has the potential to be retrofit towards zero energy balance. It is because the building consumes an optimum energy utilization which is about 40% at 6.23 kWh/m2. Therefore, the consideration of retrofit options such as lean energy, green technology and clean energy is needed because it provides an opportunity to improve the current BEI, initiatives for energy reduction and to achieve for a zero energy building. Retrofitting of existing building plays a vital role for fundamental changes to be made in commercial building especially in HLI. It has now become a great effort to improve the current building conditions in every sense and ensure for a better built environment.

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