GREENING THE EXISTING BUILDING (CHANCELLERY BUILDING - UNIVERSITY TECHNICAL MALAYSIA MELAKA)

M. K. Hussein[1*],R.B. Mat Dan[2]

[1]Mechanical Engineering Department, Al-Mustansiriayah University, Baghdad, Iraq.
[2]Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Melaka, Malaysia.

ABSTRACT

Buildings contribute significantly to the environmental and economic issues, as they consume a high amount of energy and water. As a building consumes energy, it contributes to emissions of carbon dioxide which lead to environmental pollution. These factors have a negative impact on the environment and the economy among other issues. Green building practices and approaches can considerably reduce or eliminate negative ecological and economic impacts. This study aims to "greening the existing building" and achieve the "Certified" rating level according to the GBI classification with a low budget, taking into consideration estimated cost. The green building audit results show the total current building rating level is only 18 off 100 points based on the major six criteria that shows the existing Chancellery building achieves a low rating level when evaluated according to the GBI rating system. To achieve a "Certified Rating Level" of (50 points) this study proposes short-term improvements and medium-term evaluation durations of existing building's criteria (Retrofitting). The economic analysis involves the estimation of costs included the "Greening Existing Building" and the potential savings acquired from "Retrofitting" and it shows the calculation of "Payback Period and Return on Investment (ROI)".

Keywords: *Green building; Energy audit; Retrofit; Economic analysis, Green building index*

1.0 INTRODUCTION

"Greening Buildings" is considered one of the solutions proposed to address global climate changes and economic issues due to unbalanced energy consumption in various types of infrastructure (Green Building Council, 2009) (Carroon, 2010). The global annual energy consumption of buildings is a high impact as it accounts for more than 60% of the total electricity consumption and 40% of the aggregate energy consumed. Moreover, the use of water in buildings is more than 16% of the aggregate water consumption (Zaid et al., 2013). Buildings are considered one of the causes of the global warming phenomenon since it accounts for over 40% of total carbon dioxide CO_2 emissions. While currently, United States, Canada, Western Europe, and Japan are the major contributors to greenhouse gas emissions, this situation is going to change radically in the upcoming years. (Yudelson, 2007)

The "Green Building Index (GBI)" is the recognized "Rating Tool" for green buildings in Malaysia. This encourages sustainability in the built environment, and increase

*Corresponding author e-mail: mustafakhudhur@uomustansiriyah.edu.iq

awareness of these matters among related stakeholders, including developers, contractors, and architects. The evaluation of residential and commercial properties using the "GBI Rating Tool", depends on six main criteria: "Indoor Environment Quality (EQ), Sustainable site planning & Management (SM), Materials and Resources (MR), Energy Efficiency (EE), Innovation (IN), and Water Efficiency (WE)" Alternatively, buildings are divided into the following categories: "Non-Residential New Construction (NRNC), Non-Residential Existing Building (NREB), Residential New Construction (RNC), and Residential Existing Building (REB)". There are four levels of GBI certification: "(more than 86 points) Platinum; (76 to 85 points) Gold; (66 to 75 points) Silver; and (50 to 65 points) certified" (GBI Malaysia, 2011). This study aims to "Greening" the Non-Residential Existing Building (Chancellery Building - University Technical Malaysia Melaka) and achieves the "Certified" rating level of (GBI) classification. Also, estimate the cost of greening procedure of the building and to identify the assessment criteria that most effect on the overall cost and determine the potential overall savings from retrofitting.

2.0 METHODOLOGY

The methodology which is implemented in this study consists of three phases; the first phase is the description of the building. The second phase is the Energy Audit procedure that is used to assess current building rating level according to (GBI). Energy Audit includes the Data Collection, Walk-through Tour, check List According to (GBI), Calculation of Building Criteria, Physical Measurement, and the Energy Audit Tools. The last phase is a proposed potential improvement of building criteria (Retrofit).

2.1 Description of the Building

The case study building for this study is the "Chancellery building" the building consists of three blocks: Chancellery, Plaza, and HEPA.

Figure 1. Location of Chancellery building [Source: UTeM-Development Office]

The building located in the main campus of the "University Technical Malaysia Melaka" "Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia", and the total building area is about 11212 m^2, Figure 1 below show the location of Chancellery building.

2.2 Energy Audit Procedure

Energy Audit includes the data collection, Walk-through tour, check list according to (GBI), Calculation of Building Criteria, and Physical Measurement. (Natural Resources Canada, 2009) (Fallis, 2013)

2.2.1. Data Collection

Data collection is the first step of Energy Audit, the data collected in this study includes electricity bill, water bill, building layout (civil layout, architecture layout, electrical layout and mechanical layout), and the material used in the construction of the building. It also includes data collected by the interview with the many engineers in the UTeM-Development Office.

2.2.2. Walk-through Tour

The second step is Walk-through tour, the main objective of the tour is to obtain general information about the case study building, including building envelope, ACMV system, lighting system, and operation & maintenance practices. That seeks to identify potential retrofit opportunities which can be improved the building to achieve study target.

2.2.3. Check List According to (GBI)

The third step is fill up the GBI checklist for Non-Residential Existing Building. The checklist filled up by conducting an interview with the many engineers in the UTeM-Development Office, analysis of the collected data, Walk-through Tour, calculation of some parameters and the physical measurement for many parameters.

2.2.4. Calculation of Building Criteria

The calculation of building criteria includes the "Overall Thermal Transfer Value (OTTV)" and "Building Energy Intensity (BEI)". The (OTTV) was calculated through the building involve (walls and windows) and is given by the equation (1) as shown below:

$$\mathrm{OTTV} = \frac{\mathrm{A_{O1}} * \mathrm{OTTV_1} + \mathrm{A_{O2}} * \mathrm{OTTV_2} + \mathrm{A_{On}} * \mathrm{OTTV_n}}{\mathrm{A_{O1}} + \mathrm{A_{O2}} + \mathrm{A_{On}}} \quad (1)$$

Where A1 is the total exterior wall area for orientation one and OTTV1 is the "OTTV" value for orientation one. OTTV of any given wall orientation is given by the equation (2) as shown below:

$$\mathrm{OTTV_i} = 15\,\alpha\,(1 - \mathrm{WWR})\mathrm{U_W} + 6(\mathrm{WWR})\mathrm{U_f} + (194 * \mathrm{CF} * \mathrm{WWR} * \mathrm{SC}) \quad (2)$$

OTTV=	Heat Conduction through walls	+	Heat Conduction through windows	+	Solar Heat gain through windows

Where WWR is the window-to-total exterior wall area ratio for the orientation; α the "Solar Absorptivity" of opaque wall; U_W is the "Thermal Transmittance" of opaque wall (W/m ^{2} K); U_f is the "Thermal Transmittance" of windows (W/m ^{2} K); SC is the "Shading coefficient" of the fenestration system; CF is the "Solar Correction Factor" for building orientation. (Sukri, M. F., 2012)

As well as the (BEI) was calculated by performing analysis of the electrical consumption and building floor area. The (BEI) given by the equation (3) as shown below (Noranai and Kammalluden, 2012):

$$\mathrm{BEI} = \frac{\text{Total Energy Consumed in one year (kwh/yr)}}{\text{Total Floor Space Area of the Building (m}^2\text{)}} \tag{3}$$

2.2.5 Physical Measurement

The Physical Measurement of Indoor Environmental Quality (IEQ) was conducted. Which includes Indoor Air Quality (IAQ), Mold Prevention, Daylighting, Daylight Glare Control, Electric Lighting Levels, and Internal Noise Levels.

The Indoor Air Quality (IAQ) and Mold Prevention include the flowing parameter: Average air velocity (m/s), Average fresh air flow (cfm), Average operating temperature (°C), Average relative humidity (%), and Average CO_2 (PPM). Therefore, gathering field data by doing measurements of physical parameters in order to evaluate indoor air quality for each floor in the Chancellery building. The selection of measurement points was conducted in a random manner in such a way that it covered all areas. The number of points is (5-8) points in different places on the same floor. The time spent to conduct the measurement (8:30 am to 5 pm). Every point is an average of (60) points in the same zone, and the height of the devices is 1.5 m. The role of this measurement is to characterize and compare IAQ results with GBI requirements. Where the GBI requirements are compare the results with the minimum requirements of ventilation rate in "ASHRAE 62.1:2007" (ASHRAE Standard, 2007) and/or Malaysian's Standards such as "MS 1525: 2007" (Malaysia, 2007) and "Malaysian Industry Code of Practice on Indoor Air Quality 2010" (DOSH, 2010). While the measurement of average fresh air flow (cfm), was conducted in all AHU by measuring the air velocity of fresh air and measure the dimension of the fresh air duct. (Tuan et al., 2015)

The Daylighting measurement is conducted by measure the Indoor illumination (Li), the (Li) were taken at middle points of north, south, east and west rooms by using lux meter probes located 0.8 m above floor level. Readings were logged every one hour from (10:00 am to 3:00 pm). While the Outdoor illumination (Lo) was taken from privies study was conducted in Malaysia (Fadzil et al., 2015). And then compare the result with GBI requirements.

The Daylight Glare Control is conducted by measure the Indoor illumination using lux meter probes located 0.8 m above floor level during periods of low angle sun (early mornings and late afternoons) and during periods with a bright sky. The measurement was conducted from (10:00 am to 3:00 pm), in two cases. The first case without using the Manual Blinds and the second case by using the Manual Blinds, and then compare the result with GBI requirements.

The Electric Lighting Levels measurement was conducted by dividing the work area into a small area and then take the average Electric Lighting Illumination Levels. After that compare with GBI requirements. The measurement conducted by using lux meter probes located 0.8 m above floor level.
The measurement of the Internal Noise Levels was conducted by using the sound level meter, by measure the (LAeq) (average sound level, equivalent continuous sound level). The number of points is (5-8) points in different places on the same floor and the time duration of conducting the measurement too from (8:30 am to 5 pm). The measurement involves the offices, lobby and the area near to the AHU.

The measurement devices that were used in this study are classified as follows:

- TSI 7545 Indoor Air Quality Meter
- RS AVM-0.1 Anemometer
- CENTER 337 Light Meter
- RION NA-28 Sound Level Meter

2.3 Improvement of Building Criteria (Retrofit)

After conducting the Energy Audit and obtaining the current GBI rating level. The final step is greening the existing building and achieve a "Certified Rating Level" of (50 points) according to GBI rating system, this study proposes a short-term improvements duration (4 years) of existing building's criteria (Retrofitting) and medium-term duration (8 years) to evaluate the result of implementation of the improvement to determine their effectiveness in moving towards the greening the existing building. The potential improvement includes six-part: "Indoor Environment Quality (EQ), Energy Efficiency (EE), Sustainable Site Planning & Management (SM), Water Efficiency (WE) Materials & Resources (MR) and Innovation (IN)". Below some of the potential improvement: encourage sustainable maintenance, upgrades the traditional energy lighting system, installation rainwater harvesting equipment, provide more flexible light control system like daylight sensor and motion sensor, promote innovation and environmental initiative, provide more greenery and roof to reduce heat island effects, provide co_2 sensor to monitor indoor air quality, installation renewable energy like photovoltaic (PV), install self-cleaning façade and use more green product/material in building. (Zakaria et al., 2012).

The economic analysis involves the estimation of costs included in "Greening Existing Building" and the potential savings acquired from "Retrofitting". The potential savings include cutting costs from Lighting System and Building Integrated Photo Voltage.

3. RESULTS AND DISCUSSIONS

In this study, the "Energy Audit" was conducted to assess the building assessment criteria based on the major six criteria. Energy Audit includes the Data Collection, Walk-through Tour, check List According to (GBI), Calculation of Building Criteria, and Physical Measurement.

3.1 Results of Energy Efficiency (EE)

The Energy Audit results show the current building rating level for (EE) is (9 from 38) points. As shown in Table 1 below

Table 1: Results of Energy Efficiency (EE)

Assessment	Points	Score	Assessment	Points	Score
Minimum Energy Efficiency Performance	2	0	Enhanced Commissioning of Building Energy Systems	4	4
Lighting Zoning	3	0	On-going Post Occupancy Commissioning	2	0
Electrical Sub-metering	2	0	Energy Efficiency Improvement and Monitoring	2	0
Renewable Energy	5	0	Sustainable Maintenance	3	0
Improved Energy Efficiency Performance –" BEI"	15	5			
Total Score = 9					

3.1.1 Overall Thermal Transfer Value

The "Overall Thermal Transfer Value (OTTV)" is an amount of the average rate of heat gain into a building through the building envelope and includes walls and windows for all sides (Sukri, M. F., 2012). The results show the average OTTV for Chancellery block, Plaza block, and HEPA block is (64.23, 86.88 and 70.19) W/m^2 respectively. According to the GBI requirement, all blocks do not achieve the recommendation of MS 1525: 2007 (OTTV≤50 W/m^2) (Malaysia, 2007), the building got (0 from 1 point) according to green building index (GBI/NREB).

3.1.2. Advanced or Improved EE Performance – BEI

Building Energy intensity is the amount of electric energy consumed per year per meter square, where electric energy in the kWh unit and the unit of building energy intensity is kWh/m²/yr.(Noranai and Kammalluden, 2012) In this study the building consists of three blocks: Chancellery, Plaza, and HEPA, the total floor space area of the building are (11212 m^2). The analysis of electrical consumption was based on a monthly summary report for one year (January 2015 – December 2015). The report prepared by the "Development office in UTeM" by used electrical meter, while the electrical bill involves the whole university. Figure 2 shows a summary of the estimated electricity for Chancellery Block, HEPA Block, and Plaza Block as shown below:

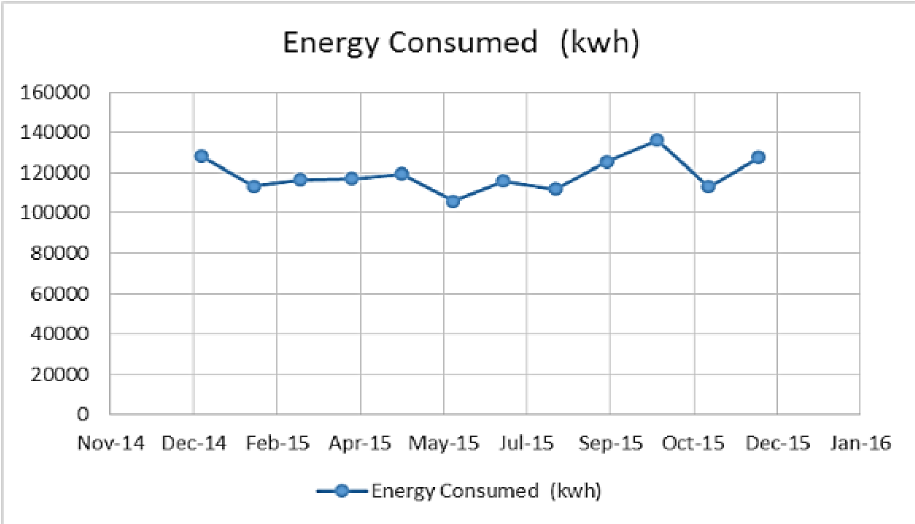


Figure 2. Electricity Consumption from (January 2015) to (December 2015)

The results show the Building Energy Intensity (BEI) is 127.55 kWh/m2/yr. and when to compare the result with the recommendations of the (GBI) building's assessment criteria the value of BEI≤130. From that the building assessment criteria for this part got (5 points from 15).

3.1.3 Enhanced Commissioning

This part includes develop a commissioning plan for the building's "Energy-Related Systems", update the building "Operating Plan", and provide "Training" for management staff to build. The Energy Audit results the building's management office (Development office) is already implemented the GBI requirements. From that the building assessment criteria for this part (4 from 4) points.

3.2 Results of Indoor Environment Quality (EQ)

The Energy Audit results show the current building rating level for (EQ) is (5 from 21) points. As shown in Table 2 below:

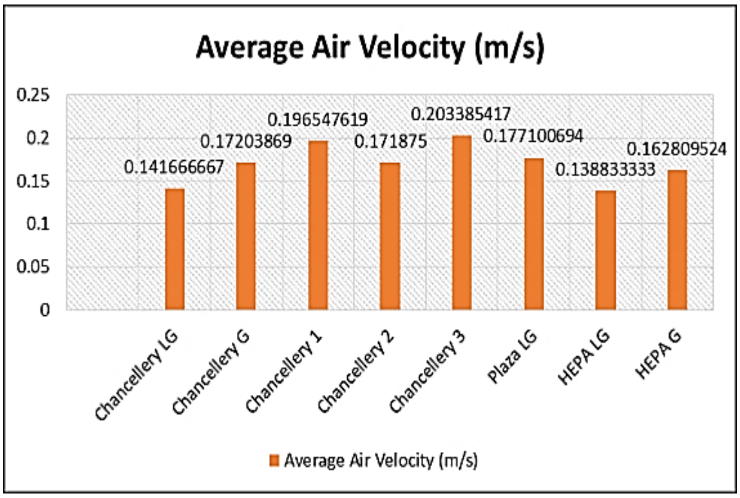
Table 2. Results of Indoor Environment Quality (EQ)

Assessment	Points	Score	Assessment	Points	Score
Minimum Indoor Air Quality "IAQ" Performance	1	1	Daylighting Factor (DF)	2	1
Environmental Tobacco Smoke Control	1	1	Daylight Glare Control	1	1
Carbon Dioxide (CO_2) Monitoring and Control	1	0	Electric Lighting Levels (lux)	1	0
Indoor Air Pollutants	2	0	High Frequency Ballasts	1	0

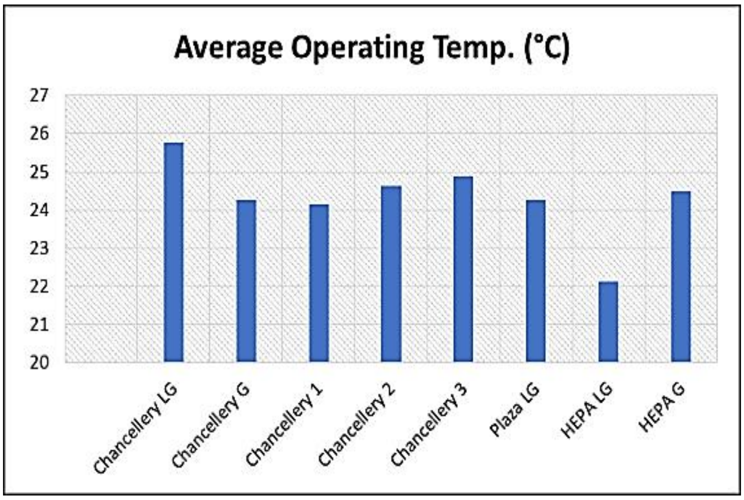
Mold Prevention	1	1	External Views	2	0
Controllability of Systems	2	0	Internal Noise Levels	1	0
Air Change Effectiveness (ACE)	1	0	Occupancy Comfort Survey	2	0
IAQ Test During Occupancy	2	0			
		Total Score = 5			

3.2.1 Indoor Air Quality (IAQ)

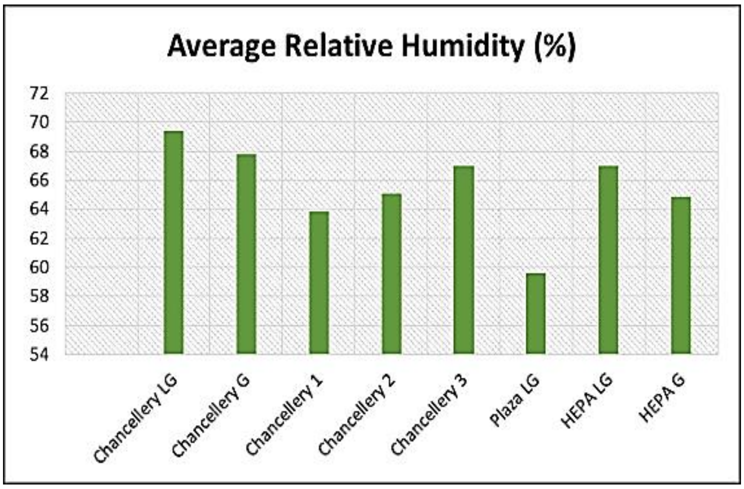
The aim of this part is to analyze data collected from the field measurements to determine and characterize the real physical Indoor Air Quality (IAQ) of the building. Figure 3 shows the fluctuation of the average air velocity (m/s), average operating temperature (°C), average relative humidity (%) and average CO_2 (PPM) at the whole building (Chancellery block, Plaza block, and HEPA block).



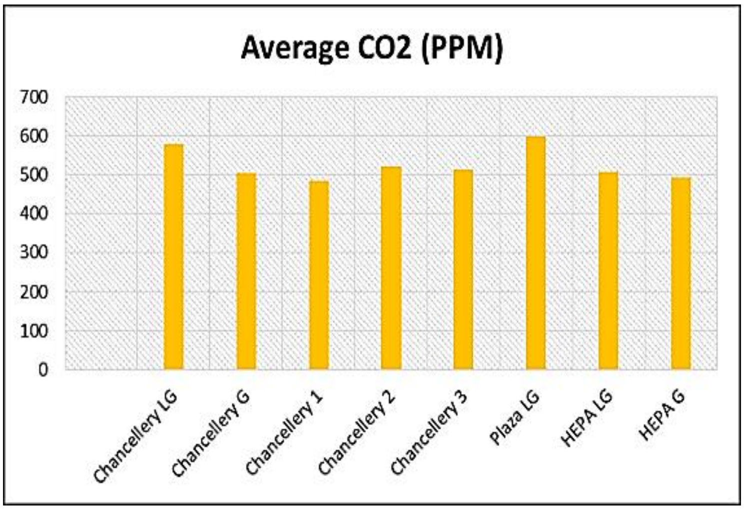
(a) Indoor Air Quality - Average Air Velocity



(b) Indoor Air Quality - Average Operating Temperature



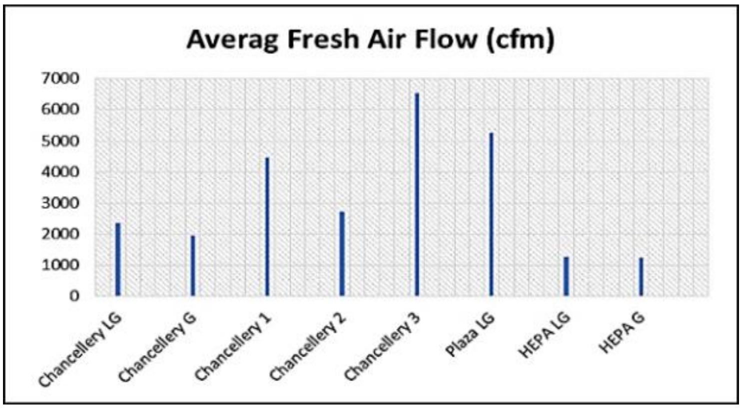
(c) Indoor Air Quality - Average Relative Humidity



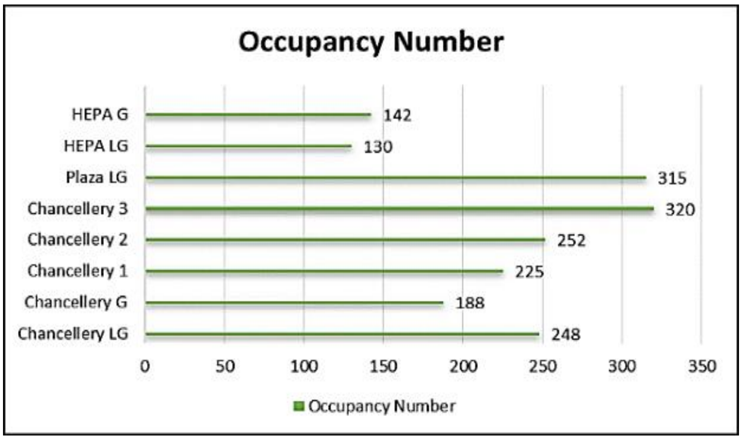
(d) Indoor Air Quality - Average CO2

Figure 3. Average IAQ Parameters at the whole Building

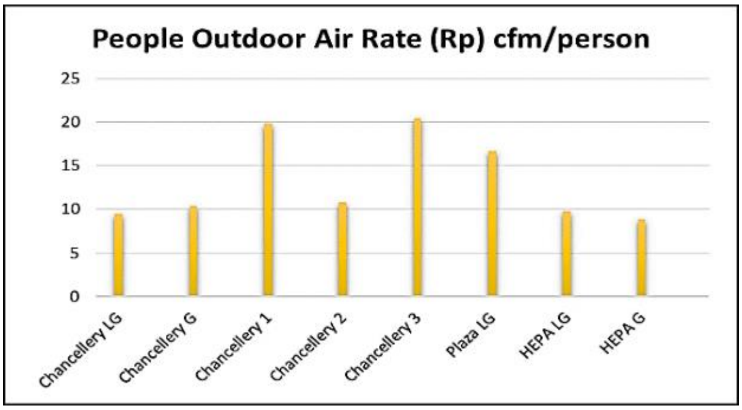
The measurement of average fresh air flow (cfm), was conducted in all AHU of building by measure the air velocity of fresh air and measure the dimension of the fresh air duct. Figure 4 below shows the average fresh air flow (cfm) for each building blocks, Occupancy Number and People Outdoor Air Rate (Rp) cfm/person.



(a) Average Fresh Air Flow



(b) Occupancy Number



(c) People Outdoor Air Rate

Figure 4. Average Fresh Air Flow (cfm) for each building blocks, Occupancy Number and People Outdoor Air Rate (Rp) cfm/person

According to the GBI requirement the results of IAQ compared with the flowing standards:

- *Malaysian "Standard MS 1525: 2007"*
  The "Indoor Air Quality" original design should be as follows: Recommended design "Dry Bulb Temperature" 23 º C to 26 °C, Minimum "Dry Bulb Temperature" 22 ° C, "Relative Humidity" (RH) 55 % to 70 %, "Air Velocity" 0.15 m/s to 0.50 m/s and Maximum "Air Velocity" 0.7 m/s.

- *"ASHRAE Standard 62.1: 2007"*
  The purpose of the standard has to specify "Minimum Ventilation Rates" and "Indoor Air Quality (IAQ)" that will be suitable to building occupants, the recommended parameters should be as flows: People Outdoor Fresh Air Flow Rate (Rp) 5 cfm and Carbon dioxide (CO_2) 500-700 ppm.

- *Malaysian "Industry Code of Practice on Indoor Air Quality 2010"*
  The purpose of this "Code" is to improving the "Indoor Air Quality (IAQ)" in the building and to set minimum value of "IAQ". The physical parameters are given as follows: "Air Temperature" 23 º C to 26 °C, "Relative Humidity" (RH) 40 % to 70 %, "Air Velocity" 0.15 m/s to 0.50 m/s and "Carbon Dioxide" CO_2 1000 PPM.

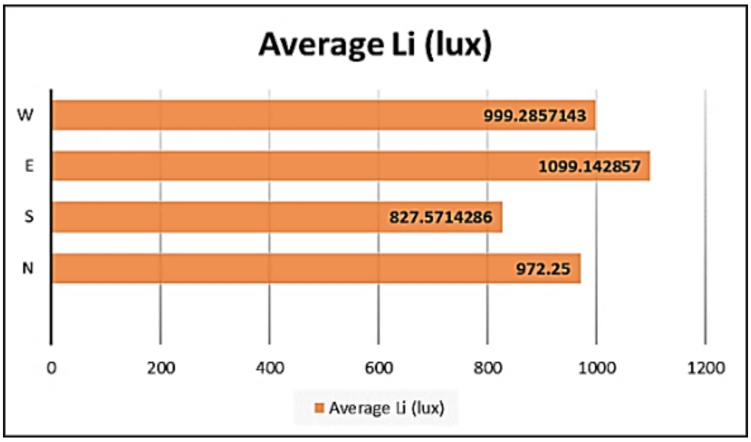
The results show the IAQ parameters, within the recommended standards. The building got (1 from 1 point) according to green building index (GBI/NREB).

3.2.2 Mold Prevention

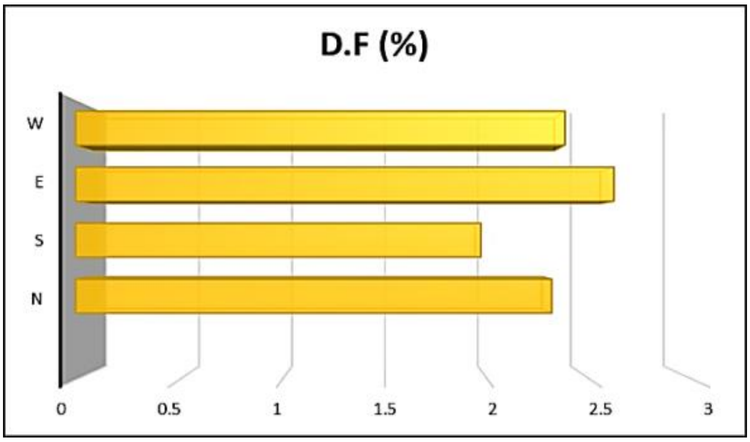
The (GBI) has recommended, the "Mechanical Ventilation System" must maintain indoor air "Relative Humidity" below 70% RH without using active regulator system. The results show that the average "overall Relative Humidity" (%) is 65.5, from that can be seen the Mold Prevention's requirements, within the recommendations of GBI. From that the building got (1 from 1 point) according to green building index (GBI/NREB).

3.2.3 Daylighting Factor

The Daylighting measurement is conducted by measure the Indoor illumination (Li) and the Outdoor illumination (Lo). Figure 5 shows the average value of Li (lux) for the (N, S, E, and W) orientations, and the Daylight Factor for each orientation. However, the total area of rooms has daylight about (4117.33 m2), the Percentage Area of rooms has daylight to the total area about (36.72 %). The CBI recommended the area of rooms ≥ 30 % or 50 % of the total area, has Daylight Factor in the range of (1 % - 3.5 %). From that the building got (1 from 2 points) according to green building index (GBI/NREB).



(a) Average value of Li (lux)



(b) Daylight Factor (D.F)

Figure 5. Average value of Li (lux) and Daylight Factor (D.F) for each orientation

3.2.4 Daylighting Glare Control

The measurement was conducted from (10:00 am to 3:00 pm), in two cases. The first case without using the Manual Blinds and the second case by using the Manual Blinds. Figure 6 below, shows the fluctuation of the indoor illumination (lux) during the time change and (with & without) using (Manual Blinds). It can be seen that the indoor illumination (lux) with using Manual Blinds smaller than without using Manual Blinds. As well as the maximum indoor illumination (lux) at 3:00 pm in both cases. The results show the average luminance level is (1718.33lux) below (2000 lux). From that the building got (1 from 1 point) according to green building index (GBI/NREB).

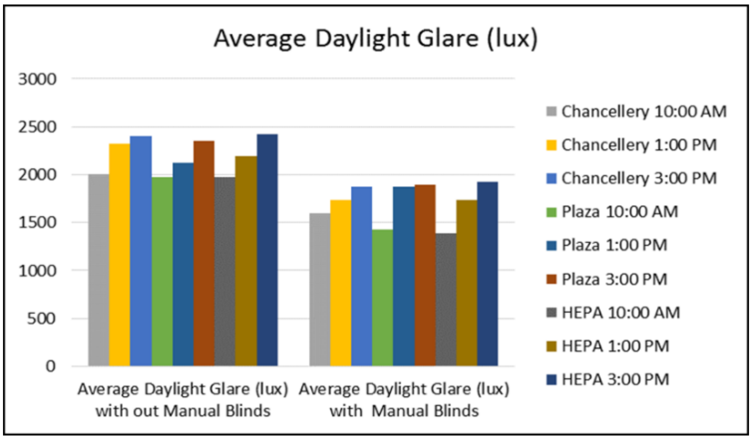


Figure 6. Results of Daylight Glare Control

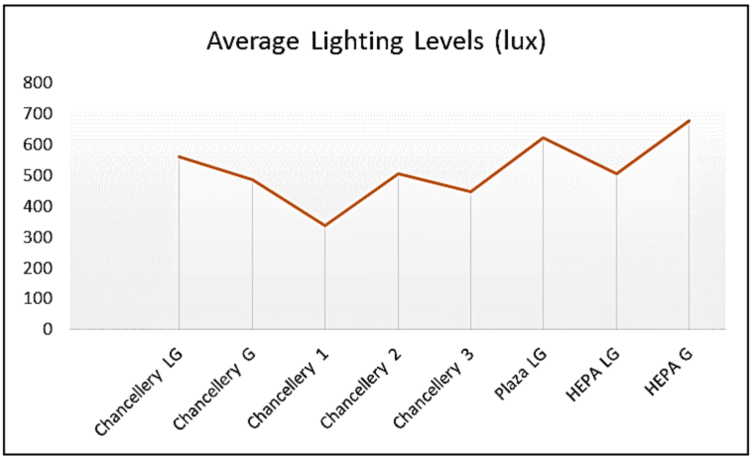


Figure 7. Average Electric Lighting Illumination Levels

3.2.5 Electric Lighting Levels

The Electric Lighting Levels measurement was conducted by divided the work area into a small area and then take the average Electric Lighting Illumination Levels. Figure 7 shows the fluctuation of the average Electric Lighting Illumination Levels at the whole building (Chancellery block, Plaza block, and HEPA block). The (GBI) has recommended that original design of electrical lighting system must maintain a "Luminance Level" not in excess of specified in MS1525 for 90% of the net lettable area (NLA), the recommended average illuminance levels for the General offices is (300-400) Lux. When to compare the Average Overall value (518.36) lux with recommended value, the Average Overall value > recommended value. From that, the building got (0 from 1 point) according to green building index (GBI/NREB).

3.2.6 Internal Noise Levels

The measurement of the Internal Noise Levels was conducted, by measure the (LAeq) (dB) (average sound level, equivalent continuous sound level). Figure 8 shows the fluctuation of the average (LAeq) (dB) (average sound level, equivalent continuous sound level) at the whole building (Chancellery block, Plaza block, and HEPA block).

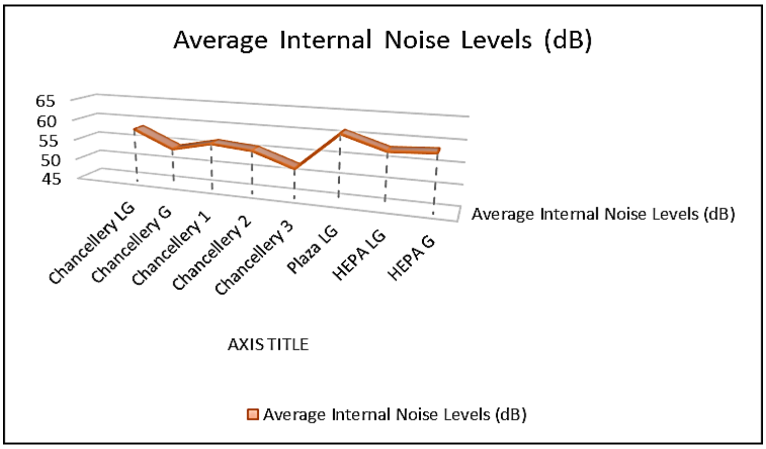


Figure 8. Average Internal Noise Levels

The GBI recommended, within the entire building general office, space noise does not exceed 40 dBA. The results show the overall average Internal Noise Levels > the recommendation. From that, the building got (0 from 1 point) according to green building index (GBI/NREB).

3.3 Results of Sustainable Site Planning & Management (SM)

The Energy Audit results show the current building rating level for (SM) is (1 from 10) points. As shown in Table 3 below:

Table 3. Results of Sustainable Site Planning & Management (SM)

Assessment	Points	Score	Assessment	Points	Score
"GBI" Rated Design and Construction	1	0	Parking Capacity	1	1
Building Exterior Management	1	0	Roof and Greenery	2	0
Landscape Management, Integrated Pest Management, and Erosion Control	1	0	Building User Manual	1	0
Green Vehicle Priority	1	0			
Total Score = 1					

3.3.1 Parking Capacity

Parking Capacity, the (GBI) has recommended that size of parking capacity not more than the minimum local zoning requirements. The Energy Audit shows the original design of the parking meets the requirements. From that the building assessment criteria for this part (1 from 1) point.

3.4 Results of Materials & Resources (MR)

The Energy Audit results show the current building rating level for (SM) is (3 from 9) points. As shown in Table 4 below:

Table 4. Results of Materials & Resources (MR)

Assessment	Points	Score	Assessment	Points	Score
Selection and Materials Reuse	1	0	Disposal of Recyclables, Storage, and Collection	3	3
Recycled Content Materials	1	0	Clean Agents and Refrigerants	2	0
Sustainable Timber	1	0			
Sustainable Purchasing Policy	1	0			
Total Score = 3					

3.4.1 Waste Management

Waste management includes the Collection & Disposal of recyclables. The "GBI" has recommended facilitating minimizing the waste generated within retrofitting construction and the occupancy of the building that is hauled and disposed of in landfills. Also, "GBI" recommended providing recycling facilities/infrastructure for separating and sorting a recyclable waste collection of for recycling, such as paper, glass consumables, equipment, and metal. The Energy Audit show building's management office is already meet the GBI requirements. From that the building assessment criteria for this part (3 from 3) point.

3.5 Results of Water Efficiency (WE)

The Energy Audit results show the current building rating level for (WE) is (0 from 12) points. As shown in Table 5 below:

Table 5. Results of Water Efficiency (WE)

Assessment	Points	Score	Assessment	Points	Score
Rainwater Harvesting	3	0	Water Efficient Fittings	3	0
Water Recycling	2	0	Metering & Leak Detection System	2	0
Water Efficient - Irrigation/Landscaping	2	0			
Total Score = 0					

3.5.1. Water Consumption Analysis

The Compliance Audit results show the water system in the building served the cooling tower, toilet, kitchen, and irrigation. The UTeM / Main Campus was provided one water meter for all building. The water consumption for Chancellery building has been estimated according to the technical information was collected from the UTeM / Development Office, as shown below :
The number of occupants = 1820, Total building floor area = 11212 m^2
Water consumption = 8 L / day / m^2
Water consumption = 89,696 L / day = 1,973,312 L / month = 23,679,744 L / year
Water consumption = 23679 m^3 / year

3.6 Results of Innovation (IN)

The Energy Audit results show the current building rating level for (IN) is (0 from 10) points. As shown in Table 6 below:

Table 6. Results of Innovation (IN)

Assessment	Points	Score	Assessment	Points	Score
Innovation & Environmental Initiatives (Max. nine points)	9	0	Green Building Index Facilitator	1	0
Total Score = 0					

3.7 Summary of Energy Audit's Results

Table 7 below shows the final Energy Audit results according to GBI. The results indicate an existing 18 points only, while the study target must obtain 50 to 66 points to get (Certified) rating level.

Table 7. Summary of Energy Audit's Results

No.	Item		Maximum Points	Existing Points
1	Energy Efficiency	(EE)	38	9
2	Indoor Environment Quality	(EQ)	21	5
3	Sustainable Site Planning & Management	(SM)	10	1
4	Materials & Resources	(MR)	9	3
5	Water Efficiency	(WE)	12	0
6	Innovation	(IN)	10	0
		Total Score	**100**	**18**

4.0 GREENING THE EXISTING BUILDING

Greening the Existing Building, involves the potential short-term improvements duration (4 years) of building criteria (Retrofit). To achieve (Certified) (50 points) rating level. The proposed potential improvements based on the major six criteria, include "Energy

Efficiency (EE)" involve labeling all lighting switches, install (50) lighting motion sensors, install (11) electrical sub-metering, install (BIPV), reducing Building Energy Intensity (BEI) by retrofit the lighting system, and sustainable maintenance plan. "Indoor Environment Quality (EQ)" involve installation (18) CO_2 sensors, develop and implement an "Indoor Air Quality (IAQ) Management Plan", and conduct "Occupancy Comfort Survey". "Management and Sustainable Site Planning (SM)" involve employing environmentally sensitive building exterior management plan, specify 5% (12 cars) of the parking capacity for low-emitting and fuel efficient vehicles, and provide a Building User Manual. "Materials & Resources (MR)" involve reused products/materials in retrofit process, used at least 75% certified wood-based materials in the retrofit process, and develop a Sustainable Purchasing Policy. "Water Efficiency (WE)" involve install Rainwater Harvesting complete system and install (5) Water Sub-Meters. "Innovation (IN)" involves using "Self – Cleaning Façade" paint ≥ 10% of total façade area (432 m^2), install "Electrochromic Glazed Façade" ≥ 10% of total façade area (120 m^2) and taking the advantage of the service of "Green Building Index Facilitator". Figure 9 below shows the comparison of the building assessment criteria before and after proposed greening existing building. It can be seen the "Energy Efficiency (EE)" and "Indoor Environment Quality (EQ)" are the heights points. The medium-term duration (8 years) is to evaluate the result of implementing the improvement to determine their effectiveness in moving towards the greening the existing building.

5.0 ECONOMIC ANALYSIS

5.1 Cost of Greening Existing Building (Retrofit)

The estimated cost of Greening the Chancellery building includes the improvement of building assessment criteria. The total cost of Greening the Existing Building is (800,764 RM). The cost involves the improvement of building assessment criteria to get additional (32 points) to achieve the study target. In addition, (EE) is the most effective part of the total cost. Figure 10 below shows the comparison between building assessment criteria cost.

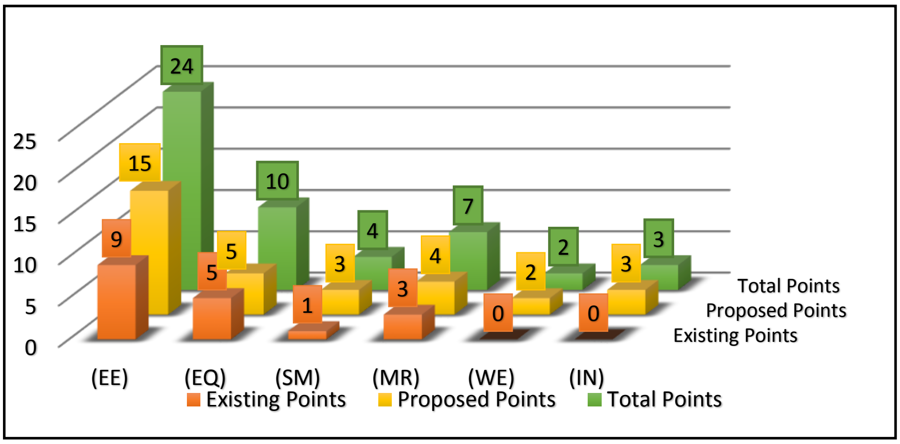


Figure 9. Comparison of the Building Assessment Criteria before and after Proposed Greening Existing Building

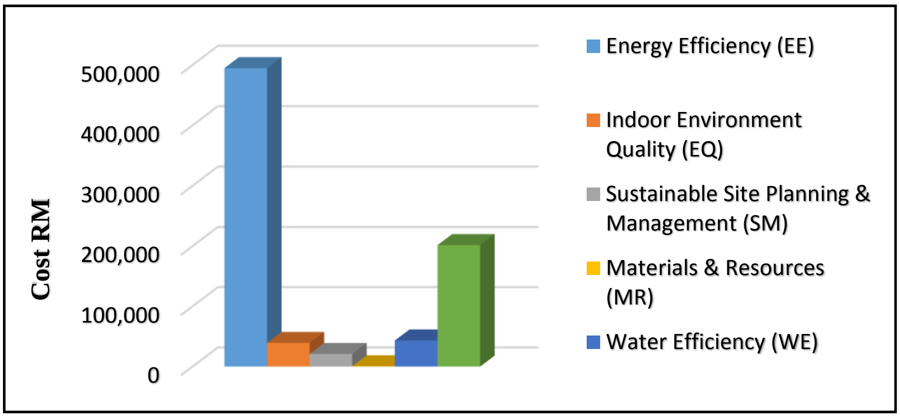


Figure 10. Comparison between building assessment criteria cost

5.2 Potential Saving from Retrofit

The potential savings include cutting costs from "Lighting System" and "Building Integrated Photo Voltage". The potential savings from Lighting System is (67345.9 RM/year) and the payback period is (1.68 years). Also, the potential saving from Building Integrated Photo Voltage is (30492RM/year) and the payback period is (4.9 years). Moreover, the total saving is (97837.9RM/year) and the payback period is (2.69 years). Figure 11 shows the current electricity consumption and the proposed energy saving from retrofitting the lighting system and installation building integrated photovoltaic (BIPV). It can be seen the total energy savings from retrofit the lighting system and installing BIPV is 296478 KWh/year. The Return of Investment (ROI) calculation results show the ROI for retrofitting lighting system is (59%), ROI for installation building integrated photovoltaic is (20%) and the ROI for retrofitting lighting system & installation building integrated photovoltaic is (37%).

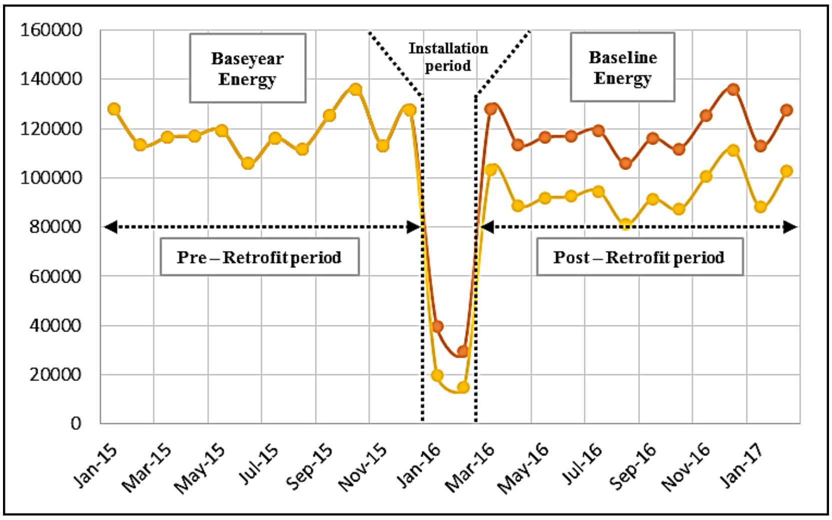


Figure 11. Power saving from the Lighting System retrofit and the proposed power generated from (BIPV)

6.0 CONCLUSIONS

Lack of control and proper power management in modern infrastructure has a negative impact on economy and environment. In a specific case, when it lacks an appropriate organization of its resources such as energy and water, buildings are considered a major key factor of this negative impact. Energy consumption in a building has many downsides, in addition to the accumulated cost of power supplied, the emissions of gasses such as carbon dioxide, as a result, is considered one of the factors of the overall environmental pollution. As a solution to these issues, green building practices and approaches can significantly reduce or eradicate negative ecological and economic impacts and offer human comfort, through innovative design, construction, siting, operation, and maintenance. This study involves the methods and techniques for greening the Non-Residential Existing Building (Chancellery Building - Universiti Teknikal Malaysia Melaka) according to "Green Building Index Malaysia (GBI)". This study concludes that existing Chancellery building achieves a low rating level when evaluated according to the GBI rating system. Hence, it requires several improvements aspects that are considered applicable under a low budget strategy.

7.0 REFERENCES

ASHRAE Standard. (2007). Ventilation for Acceptable IAQ. *ANSI/ASHRAE Standard 62.1-2007*, 62(1), 41

Carroon, J., 2010. *Sustainable Preservation: Greening Existing Buildings (Google eBook)*

DOSH, 2010. Industry Code of Practice on Indoor Air Quality. *Ministry of Human Resources Department of Occupational Safety and Health*, 1–50.

Fadzil, S.F.S., Harun, W.M.W. and Abdullah, A., (2015). A Method to Determine a Single Point Percentage Daylight Factor (%DF) Value from Field Work Data. *Advances in Environmental Biology*, 9, 39–42. Retrieved from : http://www.aensiweb.com/AEB/.

Albert T., Terry N. and William J. Y. (2013). *Handbook Of Energy Audit. Lilburn, GA : Fairmont Press ; Boca Raton, FL : Distributed by Taylor & Francis, ©2013..*

GBI Malaysia, (2011). *Non-residential Existing Building* [Online]. Retrived 5 December 2017 from: http://new.greenbuildingindex.org/how/tools

Green Building Council, 2009. *Green Building Design and Construction For the Design Construction*, U.S. Green Building Council.

Malaysia, D. of S., 2007. *MS 1525:2007: Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Building*,

Natural Resources Canada (2009). Energy Saving Toolbox – An Energy Audit Manual and Tool. *ecoENERGY*, 277.

Noranai, Z. and Kammalluden, M.N. (2012). Study of Building Energy Index in Universiti Tun Hussein Onn Malaysia. *Academic Journal of Science*, 1(2), 429–433.
Reterive from: http://universitypublications.net/ajs/0102/html/TRN168.xml.

Sukri, M. F. (2012). An analytical investigation of overall thermal transfer value on commercial building in Malaysia. *International Review of Mechanical Engineering*, 6(5), 1050.

Tuan, T.B. (2015). Energy Analysis for Lighting and Air-Conditioning System of an Academic Building. *Jurnal Teknologi*, 5, 53–56.

Yudelson, J. (2007). *Green Building A to Z: Understanding the Language of Green Building*, New Society Publishers.

Zaid, S.M., Myeda, N.E., Mahyuddin, N. and Sulaiman, R. (2013). The Need for Energy Efficiency Legislation in the Malaysian Building Sector. *The 3rd International Building Control Conference* 9,1- 9.

Zakaria, R.B. et al., 2012. Potential Retrofitting of Existing Campus Buildings to Green Buildings. *Applied Mechanics and Materials*, 178–181.42, 42–45.