Post Occupancy Evaluation Measures of Green Interiors Tools Energy Efficiency (EE) Core Criteria

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Abstract. Interior spaces sustainable rating system in Malaysian is rather new. Even though Green Building Index Interior Tools (GBI-IT) has been developed and implemented but there is lack of post-occupancy evaluation being conducted in assessing the sustainability level of the certified project, particularly on the Space Energy Intensity (SEI). Thus, embarking on the research problem whether the certified interior space sustainable level is according to the pre-occupancy scoring benchmark as vision by the designers upon occupancy, particularly on Energy Efficiency (EE). The research objective is to examine the SEI, to identify similarities and discrepancies of SEI upon pre-occupancy evaluation and post occupancy evaluation and to assess the key EE sub-criteria that affect Space Energy Intensity (SEI) and to improve continuing sustainable EE upon post occupancy. The Space Energy Intensity equation approach and implementation method is used in this research in order to measure total space energy consumption per year/interior space area. The research design will be formulated into three key stages, which are: 1. Content analysis of GBI Interior Tools EE core criteria; 2. Comparative data analysis between pre-occupancy and post-occupancy EE sub-criteria scoring and; 3. Assessment of key EE sub-criteria that affect Space Energy Intensity (SEI) and to improve continuing sustainable EE upon post occupancy. The findings for research problem based on Space Energy Intensity (SEI) on-site measure from case study will improve sustainability practice and continuing sustainable agenda particularly on EE. The study outcome will facilitate and enhance the current and future sustainable approach in interior SEI.

1. Introduction
Malaysia is a Party to the United Nations Framework on Climate Change and has ratified the Kyoto Protocol on 4 September 2004 [1]. Hence, Malaysia has moved towards a developed nations by the year 2020 and it needs to fulfill the requirements of being a developed country not only in economic and technology aspect but also in variables aspects of sustainable development. Beside the legislation of interior design professions that leads to development of GBI interiors rating beside the existing available tools. Malaysia Government support the campaign towards green building and technology as announced in 2010 Budget which comprehended [2]: the fund of not less than 1.5 billion Malaysian Ringgit (MYR) to be disburse as soft loans, tax exemption to building proprietors who acquire the new GBI certification, purchasers of buildings with GBI certification will also exempted from stamp...
duty which valid between Oct. 2009 until Dec 31, 2014 [3]. The government interventions and supports in promoting sustainable development are very important. It creates synergies and drives in the efforts of rapid modernization without compromising the environment.

Green Building Index (GBI) was introduced in Malaysia in 2009 as Malaysia first green building rating tool [4]. GBI was jointly developed by two professional bodies, the Malaysian Institute of Architect (PAM) and the Association of Consulting Engineers Malaysia (ACEM) [4]. The recognized indexing rating tool for green buildings is Malaysia’s industry is Green Building Index (GBI). Different from other rating system such as LEED, GBI Malaysia assessment criteria is designed specifically for the tropical climate while integrate Malaysia’s current social, infrastructure and economic development [5]. Hence, a new framework for developing GBI assessments criteria and methods is needed to ensure that green and sustainable interiors will reduce environmental impacts while being design-effective and socially responsive.

Green or sustainable design ideations in interior design project are gaining momentum in the Malaysia because of the high awareness on societies and the extra marketable values that it carry along the extensive and diverse project development in capital Kuala Lumpur. This is evidenced by joint effort development of Malaysian Institute of Interior Designers (MIID) and Malaysia Green Building Confederation (MGBC) in establishing the framework of Green Building Index (GBI) Tools for interior design project. Such joint effort to address the gap required in supporting the ever complex. Sustainable lifestyle and development in Malaysia especially in public interior buildings and amenities operation is imperative. The way of building designed, constructed and operated is significant to human health and environment impact. The fact that buildings required maintenance procedures, air ventilations, state-of-art equipment and 24hrs operation elevated the energy consumptions [6]. The resources used in building stressed on the importance of assessment criteria’s in Malaysia green ratings and served as an initial point for the optimum and systematic green and sustainable interior practice in Malaysia [7].

2. Research Framework

GBI for Interiors initiative aims to assist the building industry in its march towards sustainable development in interior design, architecture and urban planning as a holistic approach. The aims is to set common accepted standards; promoting integrated interior and based building from inception of the project; recognised and reward green initiatives; and relevancy of interior projects in the future. However, this pre-occupancy evaluation measures and guides for certified Green Interior Project is evaluated during design, construction and completion stage. Hence the evaluation was not done and carried out after the space is occupied by the end-users. Thus, embark to the research problem whether the certified interior space sustainable level is according to the pre-occupancy scoring benchmark as vision by the designers upon occupancy, particularly on Energy Efficiency (EE).

From the problem of this study, the framework of the study was formulated as shown in Figure 1.
2.1 Research Objectives
The study objectives are to establish the gap between pre-occupancy and post-occupancy SEI of certified interior project. There are three key objectives of the study:
1. To examine the SEI upon post occupancy in GBI certified Interior Project.
2. To identify similarities and discrepancies of SEI upon pre-occupancy evaluation and post occupancy evaluation.
3. To assess the key EE sub-criteria that affect Space Energy Intensity (SEI) and to improve continuing sustainable EE upon post occupancy.

2.2 Research Questions
The formulated research questions are to address the main objectives of the study. There are three main study questions:
1. What is the SEI upon post occupancy in GBI certified Interior Project.
2. Why similarities and discrepancies of SEI upon pre-occupancy evaluation and post occupancy evaluation need to be identified.
3. How to measure key EE sub-criteria that affect Space Energy Intensity (SEI) in order to improve continuing sustainable EE upon post occupancy.

Figure 1. Framework of Study.
3. Methodology

The scope of the study focuses on GBI-IT Energy Efficiency (EE) core criteria and certified GBI Interior project in Malaysia which were occupied for more than one year. The research methodology adopts the Space Energy Intensity equation approach in order to measure total space energy consumption per year/interior space area.

\[
SEI = \frac{\sum (l^1 + l^2 + l^3)}{F(m^2)}
\]

Where;
- Space Energy Intensity (SEI) is defined as follows:
  \[
  SEI = \frac{\text{Total Space Energy Consumption per year}}{\text{Interior Space Area}}
  \]
  \[SEI = \frac{\sum}{F}\]
- Total Space Energy Consumption per year
  - Total amount of energy used per year from all services required to operate the space
  \[\text{Air Conditioning } (l^1), \text{ Electrical Lighting } (l^2), \text{ and Plugged Load } (l^3)\]
- SEI is to be calculated within the official operating hours.
- The SEI may be rationalized for benchmarking against the industry through the following:
  - Benchmark operating hours 2700 hours per year as indicated in Table 1.

| Table 1. Factors of Operation Hours |
|-------------------------------------|
| OFFICIAL OPERATING HOURS | OPERATION HOUR FACTOR |
| 2100 | 1.29 |
| 2400 | 1.13 |
| 2700 | 1.00 |
| 3000 | 0.90 |
| 3300 | 0.82 |

The Space Energy Intensity (SEI) to gain benchmarking scores are proportionate against Building Energy Intensity (BEI) consumed for the total building measurement of energy use. In pre-occupancy evaluation, whereby the internal spaces are using centralized air conditioning systems, the energy consumption from air conditioning system used is to be acquired through the base building operation, and to be included in the SEI calculation. If this is not possible to attain, the simulated calculation may be applied in order to assess the consumed energy using centralized air conditioning system.

SEI benchmark values are derived as of formulation indicated in Table 2.

| Table 2. SEI Benchmarking based on 2700 Hours of Office Operation |
|---------------------------------------------------------------|
| Building Energy Intensity | Space Energy Intensity | A/C Energy Load | Lighting Energy Load | Plug Energy Load |
|---------------------------|------------------------|----------------|---------------------|-----------------|
| 100%                      | 55%                    | 50%           | 20%                 | 30%             |
| 150                       | 83                     | 41            | 17                  | 25              |
| 140                       | 77                     | 39            | 15                  | 23              |
| 135                       | 74                     | 37            | 15                  | 22              |
| 120                       | 66                     | 33            | 13                  | 20              |
| 110                       | 61                     | 30            | 12                  | 16              |
| 100                       | 55                     | 28            | 11                  | 17              |
| 90                        | 50                     | 25            | 10                  | 15              |

The research design will be formulated into three key stages, which are;
4. Discussions

In this study, the sequence of research process is designed in a way to achieve the objectives which derived from the main research problem statement. Based on sequence research process as indicated in Figure 2, there are three main process are conducted in concluding the findings in order to pursue continuing sustainable agendas particularly bay addressing the energy efficiency core criteria. This is vital and highly significant in sustainable measure whereby the projected EE evaluation and certification during pre-occupancy assessment is compared against the real post-occupancy assessment on-site. The yielded outcome will validate the similarity and the discrepancies between the ideal designer’s vision and the actual habitual consumption of energy in the interior spaces be it for working, living or any other routines.

The first research process, content analysis of EE core criteria in GBI Interior Tools is to identify and choose a case study of GBI Certified Interior Project. The data is obtained by examining the pre-occupancy EE sub-criteria of yearly lighting & plug load, yearly AC energy usage and total energy usage. Next is to examine space floor area, SEI, space operational hours and correction factor. This data is projected data of EE measurement and verification which was projected for Completion and Verification Assessment (CVA) submission to GBI for certification application. The SEI equations is employed in calculating this data. This scoring data is set as a baseline for the study.

The second process is to comparative data analysis of pre-occupancy EE sub-criteria scoring benchmark against post occupancy EE sub-criteria scoring benchmark. The selected case study of this research is GBI Certified Interior project which was occupied for more than 1 year. The justification for a minimum 1 year post-occupied GBI Certified Interior Project is to get the data of energy used based on actual data collection and calculations. The same method of data collection is used in measuring and calculating data of the same case study after it being occupied for more than 1 year. The gathered actual data is calculated using the same SEI equations in order the get consistency and validated results. This is very important as the research gap and research objectives on similarity and discrepancies of the variables can be identified and verified. Comparison of variables can be distinguish clearly on the EE sub-criteria energy used between pre-occupancy and post-occupancy. This is done by comparing the post-occupancy scoring data with the pre-occupancy baseline data.

Figure 2. Sequence process of the study.
Assessment of key EE sub-criteria that affect Space Energy Intensity (SEI) and to improve continuing sustainable EE upon post occupancy.

The final stage is to assess the findings from comparative data analysis of pre-occupancy and post-occupancy measures. From the findings the key EE sub-criteria that affect SEI on similarities and discrepancies based on pre-occupancy baseline and upon post-occupancy measures will be used to validate the study. The findings is then addressed how the affected SEI can be improved towards continuing sustainable EE in the future. The continuing sustainable measure on-site and at real-time, particularly on energy efficiency is vital in promoting sustainable agenda holistically and thoroughly.

5. Conclusion
Green Building Index (GBI) Tools for interior is gaining acceptance as indexing work structure in implementing green interior benchmarking issues, disagreement and management requirements. The main goal of mainstreams green management for Interior and related assessment tools is to achieve sustainable use of design resources and user experience [8]. Green Building Index (GBI) for interior project is a sustainable rating system developed by MGBC (Malaysia Green Building Confederation) and MIID (Malaysian Institute of Interior Designers). The developed GBI for Interiors will be first Malaysia’s comprehensive assessment system for assessing the sustainable design and performance of interior design project upon six (6) main factors which is energy efficiency (EE), indoor environment quality (EQ), sustainable planning management (SM), materials resources (MR), water efficiency (WE), and innovation (IN). The heading criterias set is to maintain all of standards scoring criteria in all previously developed tools in GBI rating framework system [9] The GBI for Interiors is developed specifically for the Malaysian tropical weather, environmental and developmental context, cultural and social needs [10]

Based on the discussion above, it can be concluded that projected measure of EE during pre-occupancy is important in promoting and parallel with the establishment of GBI Green Interior Tools as an effort towards sustainable development. However, it is equally important that this effort is extended by reassessing the certified green interior project particularly in EE. This vital study is to addressed on any similarities or discrepancies of EE variables between pre-occupancy and post-occupancy. The designers vision of pre-occupancy assessment are based on projected energy used of ideal scenario of building occupancy. Logically, buildings or any built environment is a ‘living organism’, it may expand to grew or declined, or even died. Hence, the actual measurement of certified green space is to get the real on-site data is important to assess the green ‘health’ of certified green space. The comparative analysis of post-occupancy data against pre-occupancy data which set as a baseline will offer similarity or discrepancy EE variables for future diagnosed.

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References
[1] Ari I and Sari R 2017 Differentiation of developed and developing countries for the Paris Agreement Energy Strategy Reviews 18 175-182
[2] MGBC 2010 Green Building Index Logo & Malaysia Green World Launched 21 May 2009 in Green Transformation. IGBC Penang. Source: http://www.greenbuildingindex.org/Resources/20100513%2020GBC%20Penang/20100513%20-%20GBC%20Penang%20-%20Green%20Transformation%20-%20Ar%20Boon%20Che%20Wee.pdf
[3] Hamid A A and Embi M R 2012 Factors for Implementing Green Building Rating Tool to Government Building in Malaysia in Asian Conference on Sustainability, Energy and the Environment Proceeding Osaka, Japan.

[4] MGBC 2010 Malaysian Prime Minister supports to Green Building Index in Green Transformation. IGBC Penang. Source: http://www.greenbuildingindex.org/Resources/20100513%20%20IGBC%20Penang/20100513%20-%20IGBC%20Penang%20-%20Green%20Transformation%20-%20Ar%20Boon%20Che%20Wee.pdf

[5] Shaikh P H, Nor N B M, Sahito A A, Nallagownden P, Elamvazuthi I and Shaikh, M S 2017 Building energy for sustainable development in Malaysia: A review Renewable and Sustainable Energy Reviews 75 1392-1403

[6] Yu W, Li B, Yang X and Wang Q 2014 A development of a rating method and weighting system for green store buildings in China. Renewable Energy 73 123-129

[7] Sahamir S R and Zakaria R 2013 Green Assessment Criteria for Public Hospital Building Development in Malaysia Procedia Environmental Sciences 20 106 – 115

[8] Rashida Y R, Sulaiman M S, Aziz A, Selamat H, Yani A H M and Kandar M Z 2011 Greening government’s office buildings: PWD Malaysia Experiences Procedia Engineering 11

[9] Lowe C and Ponce A 2012 UNEP-FI/SBCI’s Financial & Sustainability Metrics Report: An international review of sustainable building performance indicators & benchmarks. Retrieved February 28th, 2012, from UNEP-FI website: http://www.unepfi.org/fileadmin/documents/metrics_report_01.pdf

[10] Kohler N 1999 The relevance of Green Building Challenge: an observer’s perspective Building Research & Information 27 4-5