BUILDING SYSTEM SELECTION FRAMEWORK FOR ENERGY EFFICIENT BUILDINGS

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BUILDING SYSTEM SELECTION FRAMEWORK FOR ENERGY EFFICIENT BUILDINGS

by

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DECLARATION

This dissertation is submitted as an academic research for the purpose in partial fulfilment of the requirements for the Master of Science (Housing, Building and Planning) (Project Management), School of Housing, Building and Planning, Universiti Sains Malaysia. All the information submitted in this research is my work unless otherwise stated.

This dissertation has not been submitted or received in full or in part to fulfil any other degree requirement and currently it is not being presented for another degree.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACEM	Association of Consulting Engineers Malaysia
AWER	Association of Water & Energy Research Malaysia
BREEAM	Building Research Establishment Environmental Assessment Method
BEI	Building Energy Index
BIPV	Building Integrated Photovoltaic
CO_2	Carbon Dioxide
CSI	Construction Specifications Institute
CREAM	Construction Research Institute of Malaysia
EE	Energy Efficiency
EMS	Energy Management System
EPA	Environment Protection Agency
EQ	Indoor Environmental Quality
GASSIC	Green Assessment System in Construction
GBI	Green Building Index
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GPM	Green Pages Malaysia
HVAC	Heating, Ventilation & Air Conditioning
IEB	Industrial Existing Building
IN	Innovation
INC	Industrial New Construction

KeTTHA	Ministry of Energy, Water and Communication to Ministry of Energy, Green Technology and Water
LEED	Leadership in Energy and Environmental Design
MGBC	Malaysia Green Building Confederation
MR	Material & Resources
NREB	Non-residential Existing Building
NRNC	Non-residential New Construction
PAM	Malaysian Institute of Architects
RE	Renewable Energy
RII	Relative Importance Index
RNC	Residential New Construction
SEDA	Sustainable Energy Development Authority
SM	Sustainable Site Planning & Management
SPSS	Statistical Package for the Social Sciences
TES	Thermal Energy Storage
UK	United Kingdom
UNDP	United Nations Development Programme
US	United States
UV	Ultraviolet
VOC	Volatile Organic Compounds
WE	Water Efficiency
WGBC	World Green Building Council

KERANGKA PEMILIHAN SISTEM BANGUNAN UNTUK BANGUNAN CEKAP TENAGA

ABSTRAK

Sejak pelancaran konsep kelestarian di Malaysia pada tahun 2009, kawasan seluas 100 juta kaki persegi Bangunan Cekap Tenaga telah dibangunkan. Namun begitu, para penyelidik tempatan berpendapat bahawa pencapaian Bangunan Cekap Tenaga hanya setakat di peringkat awal kerana pelaksanaan Bangunan Cekap Tenaga yang tidak menyeluruh. Keadaan ini juga disebabkan oleh kurangnya pengetahuan mengenai pemilihan sistem bangunan yang dapat mengurangkan kesan "kos terawal" untuk mengekalkan prestasi bangunan. Kajian ini adalah untuk membangunkan satu kerangka pemilihan sistem bangunan yang berdasarkan objektif berikut: (1) untuk mengenal pasti faktor yang paling penting dalam pemilihan sistem bangunan yang cekap tenaga; (2) untuk menentukan sistem bangunan terbiasa dalam bangunan cekap tenaga; (3) untuk menentukan sistem bangunan yang mempunyai sumbangan tinggi kepada pretasi bangunan cekap tenaga; (4) untuk memahami selanjutnya faktor pemilihan yang paling penting dalam memberi kesan terhadap pilihan sistem bangunan; dan (5) untuk mengenal pasti halangan semasa dalam pemilihan sistem bangunan yang cekap tenaga. Satu tinjauan soal selidik dalam talian telah diedar kepada semua fasilitator Green Building Index, dan kadar respon 6% telah dicapai dalam fasa pengumpulan data. Data dianalisis dengan Relative Importance Index (RII) melalui SPSS. Di antara dapatan yang diperolehi, faktor-faktor ekonomi dan kos adalah faktor yang paling penting dalam pemilihan sistem bangunan. Pada masa yang sama, kajian ini mendapati komponen

sistem bangunan seperti penebat bumbung & rawatan; sistem pemanasan, pengudaraan & penghawa dingin (HVAC); dan tiub lampu yang cekap tenaga, merupakan sistem-sistem bangunan yang kerap digunakan dalam bangunan cekap tenaga, dan sistem-sistem ini didapati sebagai penyumbang tertinggi kepada tahap kecekapan tenaga juga. Tambahan pula, apabila salah satu sub-faktor yang paling penting, ia itu penyelenggaran dan kos penggantian di bawah faktor-faktor ekonomi dan kos telah disarikan sebagai faktor pertimbangan utama, pilihan sistem bangunan juga cenderung ke arah penebat bumbung & rawatan dan HVAC. Walau bagaimanapun, pemilihan sistem bangunan masih berdepan dengan halangan seperti kurangnya kefahaman golongan pihak berkepentingan terhadap teknik dalam sistem bangunan yang sering disebabkan oleh kekurangan akses kepada maklumat penting terhadap pelbagai jenama, kapasiti dan teknik penggunaan peralatan untuk setiap jenis sistem bangunan yang terdapat di pasaran. Maka atas dasar-dasar ini, kerangka kerja ini mencadangkan kepada pihak berkepentingan untuk mempertimbangkan tiga jenis sistem bangunan iaitu: sistem HVAC, penebat bumbung & rawatan, dan tiub lampu yang cekap tenaga, kerana penggunaaan serta aplikasi sistem-sistem bangunan ini yang tinggi dalam bangunan-bangunan cekap tenaga yang telah dibinakan. Selain itu, langkah yang paling penting adalah memastikan pihak berkepentingan mempunyai kesedaran dan maklumat yang lengkap terhadap sistem bangunan yang cekap tenaga, kerana ia dapat mengurangkan kesilapan memilih sistem bangunan. Dalam jangka masa panjang, bangunan cekap tenaga dapat mencapai maklamat Malaysia dengan mengurangkan emisi CO_2 pada tahun 2020.

BUILDING SYSTEM SELECTION FRAMEWORK FOR ENERGY EFFICIENT BUILDINGS

ABSTRACT

Ever since the launch of the sustainability drive in Malaysia in 2009, a total area of 100 million square feet of Energy Efficient (EE) buildings have been developed. However, local scholars considered this as still in the infancy stage, largely due to its poor implementation. The slow pace is also attributed to a lack of knowledge on the building system selection, where the "first cost" impact can be greatly reduced and as means to sustain the building performance. This research is to develop a building system selection framework based on these objectives: (1) to identify the most important factor in the selection of the EE building systems; (2) to determine the most common building system found in EE buildings; (3) to determine the building system that could have high contributions to the performance of EE buildings; (4) to understand the extent that the most important selection factor affects the choice of building systems; and (5) to identify the current barriers in the selection of EE building systems. An online questionnaire survey was distributed to the total population of Green Building Index (GBI) facilitators and a response rate of 6% was achieved in the data collection phase. The data was analysed with Relative Importance Index (RII) in SPSS. Among the key findings were that the economic and cost factors were considered as the most important factors during the selection of building systems for EE buildings. Simultaneously, the research found the components for building systems such as roof insulation & treatment; heating, ventilation & air conditioning (HVAC) system, and energy efficient light tube, as the

most commonly found in EE buildings and these building system themselves have the highest contribution to Energy Efficiency. Furthermore, when one of the most important sub-selection factors namely maintenance and replacement cost under economic and cost factors was abstracted as the factor to be given main consideration, the choice of building systems also tended towards roof insulation & treatment and the HVAC systems. However, the building system selection is challenged by barriers that relate to the lack of familiarity among stakeholders with the techniques in building systems, often due to the lack of access to relevant information across several range of brands, capacities and techniques to each types of building systems available in the market. With respect to this, the selection framework found that stakeholders should highly consider three types of building systems, namely: HVAC system, roof insulation & treatment, and EE light tubes, due to their high application or usage in previous EE buildings and their high contribution to the EE building assessment, as verified by GBI. Apart from that, the most important step is to ensure that the stakeholders have complete awareness and information on EE building systems, and this will reduce the wrong choices made in the selection for EE buildings. In the long run, EE buildings can achieve the Malaysia's target by reduce CO_2 emission by year 2020.

CHAPTER 1: INTRODUCTION

1.1 Background

Sustainable development refers to the development that meets present needs, without compromising on the ability of future generations to meet their own needs (Brundtland Report, 1987). Today, the issue of sustainable development is gaining great attention after the climate change, energy crisis, and environmental pollution issues (EPA, 2009) due to massive economic development taking place in past decades.

The rise of global economic activity will continue and it is estimated to increase five-fold by the year 2056, with the increment being contributed by the increase in global population, global manufacturing activity and global energy consumption (Ilha, 2009 cited in Akadiri, 2015). Therefore, the implementation of sustainable development is significant to improve the quality of life for the current and future generations (Bossel, 1999 cited in Samari et al., 2013). And, this concept has subsequently been adopted by the construction industry therein.

According to Samari et al. (2013), the foundation of the sustainable construction development in Malaysia is based on The Environment Protection Agency (EPA) of United States, which defines the sustainable building as the ‘green’ building. Hence, in order to become a green building, the designs for the building need to pass through an assessment conducted by green rating tools. To date, well-known rating tools include BREEAM in the United Kingdom (UK); LEED in the United States (US); Green Mark in Singapore; and in Malaysia, Green Building Index (GBI) is practicing. These green rating tools evaluate the design and operations of a building in its efficient use of resources, and to reduce the overall impact to the built environment.

According to Malaysian Green Building Confederation (MGBC), Green rating tools is important in Malaysia because most of the developments have been practicing unsustainable conducts. Therefore, there is a need for GBI to monitor sustainable approaches in the development, managing growth of energy consumption in the buildings, so as to reduce emissions of Greenhouse Gasses (GHGs), and the carbon footprint (AWER, 2012).

In Malaysia, buildings are consuming 53% of total electricity generated, with an annual growth rate of 6.4% (UNDP, 2009), and this has caused worry to the Malaysia government. Eventually, the Malaysian Prime Minister has promised to reduce 40% of CO_2 emissions in Malaysia by the 2020s in the Conference of the Parties (COP) Climate 15 UN Climate Summit in Copenhagen (15^{th} Conference on Parties, cited in Othman and Yahoo, 2014).

The Ministry was restructured, and the new Ministry of Energy, Green Technology and Water (KeTTHA) launched the National Green Technology Policy immediately in 2009. The Government’s policy was in the form of giving out a total of RM 1.5 billion as financial soft loans to companies that supply and utilize green technology; and with tax incentives based on the additional cost incurred to obtain the GBI Energy Efficient Building Certificate (The 2010 Budget Speech, 2009).

These incentives increased the adoption of energy-efficient technology in buildings effectively, and in 2014, GBI has announced that the certified built-up area of energy-efficient building development has reached 100 million square feet (GBI). However, Samari et al. (2013) stated that current incentive programmes are still not effective enough, as these incentive programmes are not able to recoup the high upfront construction cost of energy efficient green buildings or make them more affordable. Nevertheless, the financial issue is not the only problem; and the energy-efficient green building development concept is still new in Malaysia, and only a few had really put that into practice (Said et al., 2013).

1.2 Problem Statement

Most scholars agreed that the energy efficient (EE) building development is still in the early stages, and the industry is still facing a lot of problems (Said et al., 2013; Samari et al., 2013; Nazirah, 2009; Sood et al., 2011). The largest problem in the local construction industry was always the “first cost” impact (Samari et al., 2013; Nazirah, 2009), imposing a higher selling price, so only people in a few categories could afford it. However, according to Langdon (2007), EE buildings can be built at “no cost significant” difference based on his research on green buildings certified by LEED.

To date, the industry’s understanding to the project goals within the available budget is important for “no cost significant” green buildings (Langdon, 2007). The building materials and building systems have been identified as crucial to the feasibility of a project (Akadiri, 2015). Therefore, the selection of sustainable building materials and building systems have been identified as an important strategy in the design of a building (Akadiri, 2015), and it gives significant impact on the green certification as well (Florez et al., 2010).

Yet, the immense numbers of options for building materials and building systems have caused the task in the selection to become complex and delicate (Ogunkah and Yang, 2013). Wide options for these building systems would often cause failure in the selection, further affecting the EE building's performance due to the wrong choices of building systems selected for the buildings (Ding, 2008 cited in Ogunkah and Yang, 2013) and leading to a serious consequence of additional costs (Gluch, 2004 cited in Ogunkah and Yang, 2013).

Hence, this research saw the need to develop a building system selection framework for EE buildings, because no one has done this before in the local industry. The premise to a higher-paced development for EE building is made up from four parameters, which will enhance the knowledge in the selection of building systems for EE buildings. These parameters are found from the (1) selection factors for EE building systems; (2) building systems' application in EE buildings; (3) building systems' contribution to the performance of EE buildings; and (4) barriers in the selection of EE building systems (Ogunkah and Yang, 2013; Akadiri, 2015; Lalchand, 2009; Green Pages Malaysia (GPM, 2014).

1.3 Research Question

There are five (5) research question in this research:

I. What is the most important factor in the selection of EE building systems?

II. What is the most common building system found in EE buildings?

III. What are the building systems that have high contributions to EE building performance?

IV. To what extent does the most important selection factor affects the choice of building systems?

V. What are the current barriers in the selection of the EE building system?

1.4 Research Objectives

The objectives of the research are:

I. To identify the most important factor in the selection of the EE building systems.

II. To determine the most common building systems found in EE buildings.

III. To determine the building systems that could have high contributions to the performance of EE buildings.

IV. To understand the extent that most important selection factor affects the choice of building systems.

V. To identify the current barriers in the selection of EE building systems.

1.5 Research Methodology

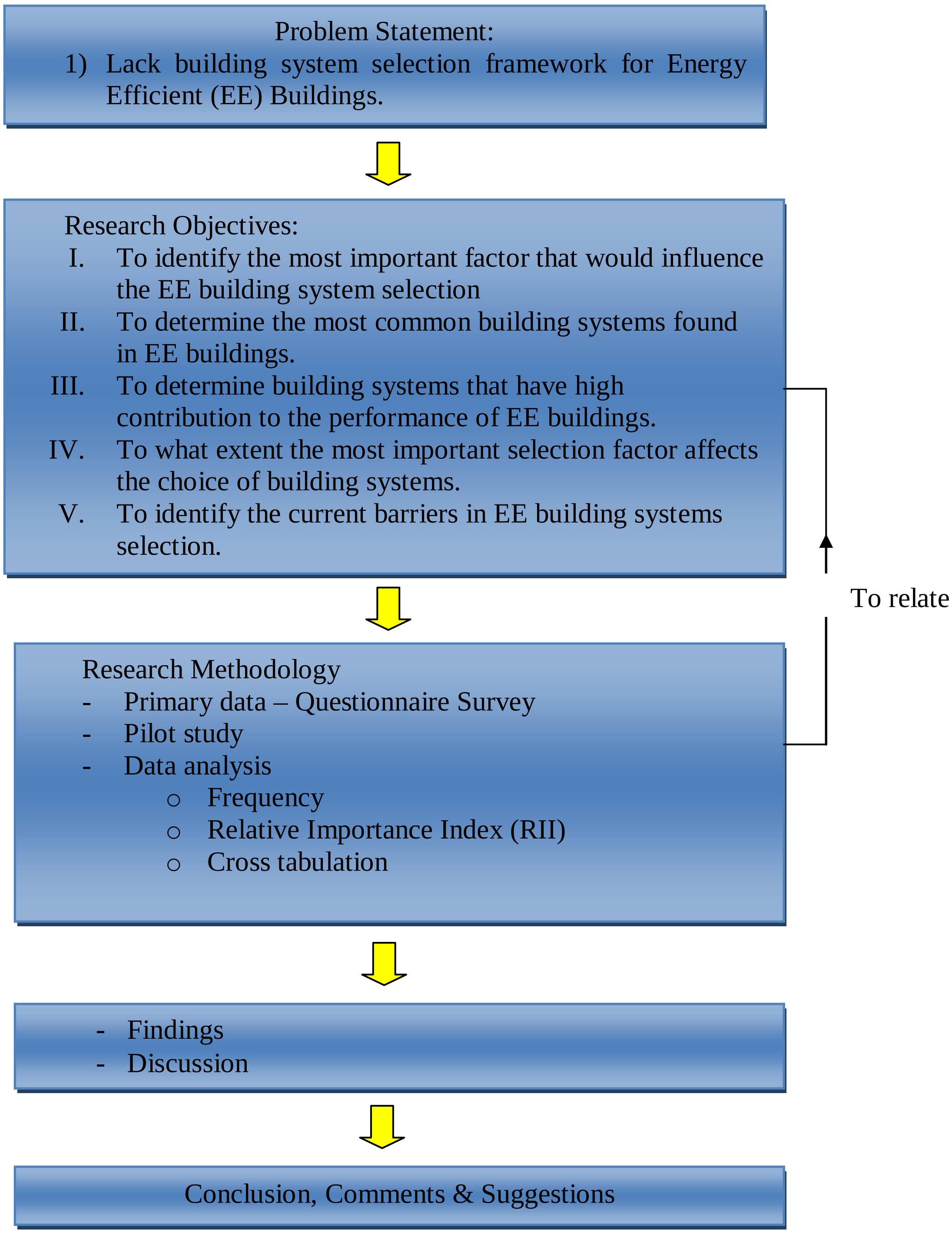
The research methodology is to develop a building system selection framework for energy efficient (EE) buildings, due to lack of this framework in the local industry. It is an important strategy in the design of a building (Akadiri, 2015), and to avoid wrong choices selected (Ding, 2008 cited in Ogunkah and Yang, 2013) that could lead to a serious consequence resulting in additional costs for EE buildings (Gluch, 2004 cited in Ogunkah and Yang, 2013). This framework consists of five objectives, which can be referred to in Section 1.4.

Research questions were designed to obtain the primary data through questionnaire survey of facilitators listed by the office panel of GBI, updated since 25th May 2015. This research gains insights into the facilitator's knowledge and experience across all buildings types that could be certified by GBI, therefore, the total of GBI facilitators are serve as the subject of this research. Most of the literature reviews were selected from online journals, articles, product directory and etc., which the most quoted are Ogunkah and Yang (2013), Akadiri (2011 & 2015), Lalchand (2009), and the product directory in Malaysia, which is Green Pages Malaysia (GPM, 2014).

A pilot study was carried out upfront to test on the reliability through Cronbach's alpha value, to reduce bias and abnormal findings (Field, 2006). All data are analysed with the Statistical Package for the Social Sciences (SPSS) version 22 to show the frequency and Relative Importance Index (RII).

Finally, findings of the research are discussed against the literature, to enhance and support the research's findings, comments and suggestion in the last chapter. The Figure 1.5 shows the complete research process.

Figure 1.5 Research Methodology



1.6 Research Scope

The research highlights the importance of EE in reducing energy consumption and emissions of GHGs. This is supported by GBI, as GBI is very concerned about EE. Among all six (6) criteria in their assessment on green buildings across various building types. The GBI assessment structure across various building types is shown in Table 1.6.

Table 1.6: Green Building Index Assessment

Green Building Index Assessment	*RNC	*NRNC	*INC	*NREB	*IEB
Energy Efficiency (EE)	23	35	33	38	38
Indoor Environment Quality (EQ)	12	21	22	21	22
Sustainable Site Planning & Management (SM)	33	16	18	10	10
Material & Resources (MR)	12	11	10	9	8
Water Efficiency (WE)	12	10	10	12	12
Innovation (IN)	8	7	7	10	10
Total Score	**100**	**100**	**100**	**100**	**100**

Reference:
*RNC – Residential New Construction (Version 3.0 updated July 2013)
*NRNC – Non-Residential New Construction (Version 1.0 updated February 2014)
*INC – Industrial New Construction (Version 1.0 updated June 2011)
*NREB – Non- Residential Existing Building (Version 1.1 updated January 2011)
*IEB – Industrial Existing Building (Version 1.0 June 2011)

Source: Summary table adapted from Green Building Index
http://www.greenbuildingindex.org/resources.html

The columns in the table are types of buildings assessed by GBI, made up of Residential New Construction (RNC); Non-Residential New Construction (NRNC); Industrial New Residential Construction (INC); Non-Residential Existing Building (NREB); and Industrial Existing Building (IEB).

The rows have the six (6) criteria as used by GBI to rate a building, and these criteria are energy efficiency (EE); indoor environment quality (EQ); sustainable site planning and management (SM); material & resources (MR); water efficiency (WE); and innovation (IN).

Among all the six criteria, EE is one of the most important criteria for green certification. As highlighted in the Table 1.6, the EE criteria contributes in between 23 percent to 38 percent across all building types, particularly to non-residential buildings.

The overall assessment points in Table 1.6 was quoted from GBI, and was previously developed by PAM and ACEM (GBI). Therefore, PAM and ACEM have the copyright and reserve all the rights to update and modify the structure of assessment in the future. GBI itself is training new facilitators, and any industry players can become their facilitators once he or she has fulfilled the minimum requirement. The qualified facilitators will be given certification and qualified to assess any building according to the assessment structure or tools structured by GBI (GBI, 2014).

1.7 Summary

The “first cost” impact was always perceived as the largest problem by the industry when implementing EE buildings practices (Said et al., 2013; Samari et al., 2013; Nazirah, 2009; Sood et al., 2011), but this statement was challenged by Langdon (2007). EE buildings can be no cost-significant (Langdon, 2007). This was supported by Akadiri (2015) and based on his research, the stakeholders must first identify the importance of building systems selection, where it affects the overall building construction cost; in addition, it affects the green certification (Florez, 2010). But, the immense numbers of option for building systems have caused the selection to become complex and delicate, often resulting in a building system that is under-performing and which led to a serious consequence of additional costs (Ogunkah and Yang, 2013).

With the problem stated above, the research has the reason to develop a framework for the selection of building system for EE buildings, and this framework contains five objectives, (1) to identify the most important factor in the selection of EE building systems; (2) to determine the most common building systems found in EE buildings; (3) to determine building systems that have high contribution to the performance of EE buildings; (4) to understand the extent that the most important selection factor affects the choice of building system; and (5) to identify the current barriers in the selection of EE building systems.

To achieve these objectives, the research sent out questionnaires to 756 GBI facilitators. The research relied on the facilitators’ knowledge and experience to uniform the parameters of this research. All the research findings were analysed with SPSS to obtain the frequency and RII values. The findings are reported in Section 4 and finally the discussion, conclusion and recommendation are reported in Section 5.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

The research selects its literature based on reading materials that relate to the building systems on Energy Efficient (EE) buildings. These literature references will be reviewed in this chapter and to develop the research conceptual framework. Conclusion made from these referred literature would become the literature reviews to the research findings and to be recalled when discussing the findings of the research. Overall, there are three sub-titles in the chapter. To start off, the research defines the definition of green buildings and EE buildings. Further down, they explain precisely the development of EE in the building sector, and problems which occur in the development. The literature tells the four independent parameters in the selection of EE building systems that affects the development of EE buildings. There are the selection factors, contribution and application of building systems and the barriers that occur during the selection.

2.1 Energy Efficient Building

Being Energy Efficient (EE) in buildings means lesser energy is utilised to carry out similar or more work without jeopardizing the comfort or actual desired output (AWER, 2012) in a building. A building is more EE if it delivers more services for the same energy input or same services on a lesser energy input. Zainordin et al. (2012) mentioned that EE buildings improve the comfort levels of the occupants and reduce energy use (electricity, natural gas, etc.) for heating, cooling, and lighting. In that way, a well-designed EE building maintains the best environment for human habitation while minimizing the cost of energy (Janssen, 2004).

There are two ways to achieve EE in a building, either with passive design or active design. The passive design is stated to be primary, where the building envelopes should maximize natural resources to serve the building, concurrently reducing dependency of the building on electrical or electronics services. Active design is the secondary idea that allows all EE components to be built with smart systems and maximizing the EE level. Janssen (2004) claims that an improvement in energy efficiency can be considered if any action is undertaken by a producer or a user of energy products that decreases energy use per unit of output, without affecting the level of service provided.

2.1.1 GBI Assessment Criteria on Energy Efficient Building

By referring to Table 1.6, energy efficiency is one of the important criteria in the GBI assessment, and it contributes around 30% to the overall GBI assessment for a green building, for instance, in a non-residential building, the EE criteria contributes 35 marks out of 100 marks. GBI has given out the detailed description for the EE criteria in buildings and it was attached in Appendix 1.

This detailed description for EE is working as a guideline for all stakeholders who wish to score in the EE criteria during their application, in order to obtain a green certificate for their project. As in Appendix 1, the main idea of EE is sub-divided from EE1 to EE9, and each has been specified by GBI. The research would like to have a summary explanation on Appendix 1, while the full version can be referred as per attached together with this research. There are three main parts in the EE criteria; (1) the Design; (2) the Commissioning and (3) Verification and Maintenance (GBI, 2014).

In the Design part, a total of 25 marks are allocated from EE1 to EE5. In EE1, GBI has fixed a baseline for the calculation of energy consumption based on the Building Energy Intensity (BEI), and with the condition that the landlord allows energy management control system for a building that has air-conditioned services larger than $4000m^2$. The following EE2 requires the landlord to allow sensors in lighting to save energy from unnecessary lighting operation in an area that receives daylight or non-occupancy areas. EE3 is designed for a sub-dividing metering system to enhance energy management, either it is by floor, tenant or any building parts requiring more or equal to 100 kVa. Referring to EE4, GBI is encouraging on-site energy casting or renewable technology in the building, and the higher the ability in renewability, the higher the points given by GBI. EE5 is a distribution mark according to the BEI value, where higher marks are allocated for low BEI value that respectively separates into seven levels.

In the Commissioning part, GBI allocates five (5) marks for EE6 and EE7. GBI is encouraging the landlord and all consultants to appoint a specialist to develop a systematic plan and an integrated implementation plan. This is to ensure that the energy efficiency function is working effectively. The Commissioning team should ensure that training is provided and briefing is given to all future tenants on the workings of EE technology in the building, and carrying post-commissioning and testing after the building is in operations, either within 12 months from practical completion or after having achieved 50% occupancy.

On the final stage of Verification and Maintenance, 5 marks is allocated for EE8 and EE9, as GBI is depending on the landlord to check the Energy Management System for monitoring purposes. Also, GBI requires the landlord to provide a documentary plan for maintenance purposes and therefore to ensure that all EE systems and technology have a continuity in performance.

The research quotes the measurements of Building Energy Intensity (BEI), as introduced in EE5 – Advance EE performance. Other requirements stated for Energy Efficiency in Appendix 1 are clear and can be easily fulfilled, but there need some mathematical calculations on the BEI value. Therefore, it is important if the landlord could understand the formula, while the BEI value will be identified if a building is EE. The BEI calculation goes as follows:

$$\text{BEI} = \frac{TBEC - CPEC - DCEC}{(GFA\ excluding\ \ carpark\ - DCA - GLA\ x\ FVR)\ x\ (\frac{52}{WOH})}$$

*TBEC: Total Building Energy Consumption (kWh/year) for all areas
*CPEC: Car Park Energy Consumption (kWh/year) for car park areas.
*DCEC: Data Centre Energy Consumption (kWh/year) etc. control room
*GFA excluding car park: Gross Floor Area excluding car park.
*DCA: Gross area of Data Centre
*GLA: Gross Lettable Area refers to the total functional area used for commercial purpose

*FVR: Floor Vacancy Rate
*52: 52 typical weekly operating hours
*WOH: Weighted Weekly Operating Hour

Reference: Chen (2009), *Seminar on Green Building Index Malaysia, GBI Non-Residential New Construction.*

BEI is a calculation of the energy consumption of a building for a year. The calculation excluded the energy consumption in a car park and data centre or more likely being referred to as the control room. To provide a fair calculation, the user of this BEI calculation is required to have the building's vacancy rate and building's operating hours. GBI recommends the user or facilitators to use BEIT Software to calculate the BEI value.

Referring to Appendix 1, item EE5 - Advance of EE Performance, GBI gives only 2 points for the building that scores BEI that is equal or more than 150kWh per meter square (m2), and respectively, the lower the BEI value the higher the points that will be given. The highest under this item was 15 points, and the minimum BEI requested was 90 or lesser.

2.1.2 Energy Efficient Building Development

In Malaysia, the building sector consumes more than half of the electricity generated by the nation, recording at 53%; emitting 5,301 kilotons of Greenhouse Gas (GHG), with an annual growth rate of 6.4% (UNDP, 2009). Based on a study in the developed countries, the building industry is exploiting 30-40% of the natural resources, using 50% of the energy for heating and cooling, about 40% of the worldwide material consumption (Bourdeau, 1999). Scholars agree that improving energy efficiency in buildings is one of the cost-effective measures for reducing carbon dioxide emissions, GHG emissions and global warming (Sood et al., 2011).

During the Copenhagen Summit, the Malaysian Prime Minister has expressed the commitment to reduce the nation's carbon dioxide emissions by as much as 40% by 2020, from the baseline year of 2005 (15^{th} Conference on Parties cited in Othman and Yahoo, 2014). As a result, the government is working on the Green Technology Roadmap for a low-carbon, green growth economy. Currently, many new agencies, either government or non-government organizations, have been enforced local EE building practices, which include the Green Building Index (GBI), Construction Research Institute of Malaysia (CREAM), Green Assessment System in Construction (GASSIC), and Malaysia Green Building Confederation (MGBC).

After a few years of involvement in green technology, the construction industry in Malaysia is winning some achievements. One of the significant achievements is that Malaysia is now arrived at least 100 million square feet of development area of EE buildings in year 2014(GBI, 2014). Besides, Cyberjaya and Putrajaya have been planned as a showcase for Green Technology; in early 2014, the Petaling Jaya City Council had called up on all projects under their authority to fulfill the compliance by GBI before the construction planning could be given approval (Putrajaya Corporation, 2012).

Although a few achievements have been verified by the industry, scholars concede that the EE building development is still in the infancy stage (Said et al., 2013; Samari et al., 2013; Nazirah, 2009; Sood et al., 2011). There is merely but a small number of projects that have initiated energy efficiency and ecological concepts (Nazirah and Aini, 2013). The sustainability concept is "always there" but the implementation is very poor (Said et al., 2013). Therefore the research found a selection framework on building systems for EE buildings can improve the implementation of EE and sustainability concept to the developments based on literature reviews in section 2.1.3.

2.1.3 Lack of Building System Selection Framework for Energy Efficient Building

There is lack of a building system selection framework for EE buildings. Although some have perceived that the "first cost" impact to build green is always the largest barrier (Samari et al., 2013; Nazirah, 2009), the selection of building systems have been identified as an important strategy to identify the building design (Akadiri, 2015), the green certification (Florez et al., 2010) and avoiding additional cost (Ogunkah and Yang, 2013), and that it is possible to have a "no cost-significant" EE building (Langdon, 2007).

Theoretically, Green building or EE buildings have a higher “first cost” due to longer design times and use of non-standard materials or systems, and this has become the most common reason cited in studies for not incorporating green elements into building designs (Morris, 2007). The “first cost” is an initial cost of uplifting the quality of building systems compared to conventional practices. However, the “first cost” impact can be reduced if the building system selection framework is successfully increasing industry players’ knowledge in selecting building system for EE buildings.

An immense number of options for building materials and building systems have resulted in the task of selection to become complex and delicate (Ogunkah and Yang, 2013). These would often result in the failure of building systems and underperformance due to wrong choices made (Ding, 2008 cited in Ogunkah and Yang, 2013) and leading to a serious consequence of additional costs; besides, this has affected the overall performance of the building (Gluch, 2004 cited in Ogunkah and Yang, 2013).

The spending costs on building systems and labour are the primary elements in the total construction cost. Therefore, knowledge in the selection of building systems is important to avoid unnecessary construction costs being spent on the wrong building systems selected for the EE buildings, consequences the wrong selected building systems would affect the EE building performance (Ding, 2008 cited in Ogunkah and Yang, 2013).

It is also supported by Langdon (2007) in saying that the industry players’ understanding of the assessment structure is the key to building “no cost-significant” EE buildings as compared to conventional buildings, to the extent that, he refers to the building systems that have contributed to every feasibility points to the green building assessment, in order to let the buildings to obtain the green certification from the rating tools likes LEED, Green Mark, GBI and etc (Florez et al., 2010).

When financial support by the government is not able to recoup the “first cost” of a building green (Samari et al., 2013), and with developers are now aware on the rising issue of sustainability, there is little effort in implementing it due to high “first cost” (Nazirah 2009; Said et al., 2013). Therefore, the research has foreseen a selection framework for building systems of EE buildings can resolve the issue of high “first cost” by reducing wrong choices of building systems selected in EE building (Ding, 2008 cited in Ogunkah and Yang, 2013). Besides, the selection framework of building systems can be an important strategy during building design (Akadiri, 2015) to monitor and control the main problem that caused the high “first cost” and respectively caused other problems and had affected the pace of EE green building performances and development.