CHALLENGES AND BENEFITS OF IMPLEMENTING GREEN BUILDING TECHNOLOGY IN BUILDING CONSTRUCTION PROJECTS

LIM ZEN YANG

SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2019

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By

LIM ZEN YANG

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfilment of requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)
(CIVIL ENGINEERING)

School of Civil Engineering,
Universiti Sains Malaysia

January 2019

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2018/2019

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: Challenges and Benefits of Implementing Green Building Technology in Building Construction Projects

Name of Student: LIM ZEN YANG

I hereby declare that all corrections and comments made by the supervisor(s) and examiner have been taken into consideration and rectified accordingly.

Signature: Approved by:

_____ _____

(Signature of Supervisor)

Date : Name of Supervisor :

Date :

Approved by:

_____

(Signature of Examiner)

Name of Examiner :

Date :

ACKNOWLEDGEMENT

First of all, I would like to express my deepest appreciation to my supervisor, Dr. Sharifah Akmam Syed Zakaria who always showed me helpful guidance and advices in the completion of this dissertation. She consistently showed her support and steered me in the right the direction whenever she thought I needed it.

I would also like to extend my sincere thanks to the School of Civil Engineering, Universiti Sains Malaysia for providing support and assistance during the data collection process of my questionnaire survey.

I am also particularly grateful for the feedbacks of all the respondents who participated in this research. Without their active participation, the questionnaire survey could not have been successfully conducted.

Finally, I must express my very profound gratitude to my family who gave me unconditional support and encouragement throughout my years of study and through the process of writing this dissertation. This accomplishment would not have been possible without them. Thank you.

ABSTRAK

Teknologi bangunan hijau (TBH) ialah aplikasi proses-proses yang bertanggungjawab terhadap alam sekitar dan keberkesanan sumber-sumber sepanjang kitaran hayat sesuatu bangunan. TBH telah meningkatkan kesedaran awam dalam tahun-tahun kebelakangan ini disebabkan oleh perubahan iklim global. Industri pembinaan turut sedar bahawa sumber-sumber asli akan kepupusan jika ia tidak mengamalkan pembangunan lestari. Berdasarkan fakta bahawa rekabentuk alam pembinaan mempunyai pelbagai kesan terhadap kita semua, pakar-pakar mula memfokuskan kepada rekabentuk dan pembinaan bangunan-bangunan menggunakan praktik-praktik lestari yang akan menyokong industri pembinaan dengan suatu cara yang lebih bertanggungjawab untuk menangani sumber-sumber asli. Adalah dijangkakan output pengeluaran global meningkat dengan signifikan menjelang tahun 2030. Bagi menjaga alam sekitar untuk generasi akan datang, adalah penting untuk melaksanakan TBH dalam industri pembinaan. Disebalik pelbagai faedah TBH, perlaksanaan TBH di Malaysia adalah masih lambat disebabkan pelbagai cabaran. Kajian ini bermatlamat untuk mengenalpasti cabaran-cabaran dan faedah-faedah perlaksanaan TBH dan mengukur pemberat diantara cabaran-cabaran dan faedah-faedah melaksanakan TBH dari perspektif kelestarian. Hasil dari kajian soal-selidik menunjukkan bahawa cabaran-cabaran perlaksanaan TBH adalah lebih signifikan dari faedah-faedah perlaksanaan TBH. Cabaran yang paling signifikan ialah "peranan kerajaan dalam mempromosikan teknologi bangunan hijau" dengan Indeks Penting Relatif (RII) sebanyak 4.54, daripada 5.00. Adalah diharapkan kajian ini dapat membantu pihak-pihak berkepentingan dalam industri pembinaan untuk memahami perlaksanaan TBH bagi membuat keputusan dan pembangunan polisi, selain boleh digunakan sebagai rujukan untuk kajian perbandingan masa depan..

ABSTRACT

Green building technology (GBT) is the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle. GBT has raised the public's awareness in recent years due to global climate change. The construction industry is also aware that natural resources will be depleted if it does not practise sustainable development. Based on the fact that the design of built environment has various impacts on all of us, experts are beginning to focus on the design and construction of buildings using sustainable practices that will support the construction industry with a more responsible way to manage natural resources. Global construction output is predicted to grow significantly by year 2030. In order to preserve our environment for future generations, it is important to implement GBT in the building construction industry. Despite the enormous benefits of GBT, the implementation of GBT in Malaysia is still considered as slow due to various challenges. This study aims to determine the challenges and benefits of GBT implementation and to measure the weightage between the challenges and benefits of implementing GBT from sustainability perspectives. The result from questionnaire survey shows that the challenges of GBT implementation are more significant than the benefits of GBT implementation. The most significant challenge is "the role of government in promoting green building technology" with a Relative Importance Index (RII) of 4.54, out of 5.00. It is expected that this study can assist the construction industry's stakeholders to understand GBT implementation for decision making and policy development, besides can be used as a reference for future comparative studies.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Name	
GBT	**G**reen **B**uilding **T**echnology
TBH	**T**eknologi **B**angunan **H**ijau
RII	**R**elative **I**mportance **I**ndex

CHAPTER 1

INTRODUCTION

1.1 Background

Green technology is the development and application of products, equipment and systems used to conserve the natural environment and resources, which minimises and reduces the negative impact of human activities (National Green Technology Policy, 2017). Generally, green building technology (GBT) refers to the application of green technology in building construction projects. Finally, the completed building can be known or labelled as green building.

Green building is an outcome of a design which focuses on increasing the efficiency of resource use energy, water, and materials while reducing building impacts on human health and the environment during the building's lifecycle, through better siting, design, construction, operation, maintenance and removal (Frej and Browning cited in Esa et al., 2011).

A green building can also be referred to a building that, in its design, construction or operation, reduces negative impacts, create positive impacts on our climate and natural environment, preserve precious natural resources and improve our quality of life (What is green building, 2016-2018).

According to the World Green Building Council, any building can be a green building , whether it is a home, office, a school or a hospital, provided it includes these features such as the efficient use of energy, water and other resource, use of renewable energy, pollution and waste reduction measures, enabling of re-use and recycling,

delivering good indoor air quality, avoiding harmful and toxic materials and chemicals, use of ethical and sustainable materials, consideration of the environment in design, construction and operation, consideration of quality of life of occupants and a design that enables adaptation to a changing environment (What is green building, 2016-2018).

However, not every green building need to be of the same characteristics. Different countries and regions have a variety of characteristics such as distinctive climate conditions, unique cultures or diverse building types and ages. These characteristics shape and affect the design of green buildings. Therefore, in this research, the challenges and benefits of green building technology are be analysed from global, regional and local perspectives.

Occasionally, the terms green building technology and sustainable development are used interchangeably. Sustainable development can be defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations General Assembly, 1987).

Sustainable development is not only about the concern of environmental aspects but also the integration of many aspects. The overall goal of sustainable development is the long-term stability of the economy and environment; this is only achievable through the integration and acknowledgement of economic, environmental, and social concerns throughout the decision making process (Emas, 2015). The key principle of sustainable development underlying all others is the integration of environmental, social, and economic concerns into all aspects of decision making (Dernbach cited in Emas, 2015).

Buildings worldwide consumed 40% of the world's energy generation, 12% of fresh water in earth, and contribute 40% of the waste sent to landfills (Green Technology

Master Plan Malaysia, 2017). A recent study in developed countries revealed that 30-40% of natural resources were exploited by the building industry, 50% of energy used for heating and cooling in buildings and almost 40% of world consumption of materials converts to built environment (Bourdeau cited in Kamar and Hamid, 2011).

In Malaysia, residential and commercial buildings consumed about 15% of total energy. Based on the National Energy Balance 2014, the electricity consumption in Malaysia's buildings was still expected to rise (Green Technology Master Plan Malaysia, 2017). In the waste sector, it was recorded that more than six million tonnes of waste has been generated of which a quarter was produced in the Klang Valley alone (Yusoff cited in Kamar and Hamid, 2011).

Therefore, the Green Technology Master Plan (GTMP) was proposed to promote sustainable development to reduce the environmental impacts of manufacturing and construction activities in Malaysia. GTMP is fundamentally an outcome of the Eleventh Malaysia Plan (2016-2020) which has earmarked green growth as one of six game changers altering the trajectory of the nation's growth (Green Technology Master Plan Malaysia, 2017).

The national targets for energy sector and building sector from 2020 to 2030 are specified in Table 1.1 and it shows the targets of Energy Efficiency (EE) and Renewable Energy Mix (RE) were going well and possible to reach the target by the expected period. However, in the building sector, it is discovered that the current situation of national targets on green building practice is still far from optimistic (Green Technology Master Plan Malaysia, 2017), (Malaysia Biennial Update Report To The UNFCCC, 2016).

Table 1.1: The National Targets to be achieved in the future in Malaysia.

Sectors / Areas	Current Year	Target Year		
		2020	2025	2030
Number of green buildings	Year 2013 244	550	-	1750
Carbon Dioxide (CO_2) emission reduction of green buildings ($ktCO_2$ eq)	Year 2013 71.3	956.6	-	-
Energy Efficiency (EE)	Year 2014 1.5%	-	10%	15%
Renewable Energy Mix (RE)	Year 2016 18.4%	20%	23%	30%
Public projects with 70 IBS score	Year 2016 24%	100%	-	-
Private projects with 50 IBS score	Year 2016 14%	100%	-	-

Table 1.1 indicated that the implementation of green building technology in Malaysia's building industry was not performing well as the target could not possibly be achieved within expected period (Green Technology Master Plan Malaysia, 2017), (Malaysia Biennial Update Report To The UNFCCC, 2016).

Green Building Index (GBI) was the first green rating tool in the Malaysian construction industry developed to promote sustainability in the built environment and raise awareness about environmental issues. The rating criteria for a GBI involves six areas: water efficiency, energy efficiency, materials and resources, sustainable site planning and management, indoor environment quality and innovation (GBI Rating Tools, n. d.)

By 15 March 2018, there was a total of 19 million square metre gross floor area of GBI rated buildings. The carbon dioxide emission reduction of GBI rated buildings was equivalent to 892,000 tonnes or 892 ktCO_2eq/year (GBI Executive Summary, 2018).

According to the Building and Construction Authority of Singapore, since the launch of the Green Mark Scheme in 2005, the number of green mark building projects in Singapore reached 2008 in year 2013. While in January 2017, the Green Mark Gross Floor Area (GM GFA) reached 88 million square metre (Singapore Experience: Formulating and Implementing Environmental Sustainability Requirement for our Building Industry, 2017).

Table 1.2: Comparison of number of green building projects and green gross floor area (million square metre) between Malaysia and Singapore.

Country	Number of green buildings projects	Green gross floor area
Malaysia	244 projects in year 2013	19 x 10^6 m^2 in March 2018
Singapore	2008 projects in year 2013	88 x 10^6 m^2 in January 2017

From Table 1.2, it shows the difference of 1764 green building projects in 2013 between Malaysia and Singapore. In fact, the number of green building projects in Singapore in 2013 was 800% of Malaysia's green building projects. Furthermore, the green gross floor area in Singapore was 88 million square metre in 2017 which was 400% of Malaysia's green gross floor area in 2018 (Malaysia Biennial Update Report To The Unfccc, 2016), (GBI Executive Summary, 2018), (Singapore Experience: Formulating and Implementing Environmental Sustainability Requirement for our Building Industry, 2017).

Central Intelligence Agency, CIA. The World Fact Book: Malaysia (2006) revealed that even though Malaysia has a total land area of 329,847 km^2 while Singapore's land area is only 721.5 km^2; Malaysia is still falling behind Singapore in terms of sustainable development in the construction industry (Total Land Area of Singapore, Singapore Land Authority, 2017). As a result, Malaysia has an urge to keep up the pace of implementing green building technology in building construction.

1.2 Problem Statement

With the rising awareness of general public regarding the benefits and importance of green technology, the implementation of green building technology in the building construction industry of Malaysia is still unsatisfied and falling behind. Therefore, policy makers have been taking actions towards the implementation of National Green Technology Policy (NGTP) (Suhaida et al., 2013).

As presented earlier,

Table 1.2 (Section 1.1) shows that the implementation of green building technology in the building projects of Malaysia is still not going well as compared to Singapore. This signifies that green building is still not a common practice in Malaysia because of the existence of unique challenges even though there are incentives and encouraging policies from the government. Therefore, as located next to Malaysia, Singapore can be one of the best example for Malaysia in the implementation of GBT.

In order to meet green building development in Malaysia and to keep up the global pace in sustainable development, this research was be conducted to identify the common challenges encountered during the implementation of green building technology faced by the building construction industry in Malaysia, to determine the

cost-benefits of implementing green building technology in building projects and analyse the weightage of challenges and benefits of green building technology.

So far, there is no specific research on the analysis of the challenges and benefits pertaining the implementation of green building technology in Malaysia. There are various research in Malaysia that have been discussing on the challenges and benefits of green building technology from various perspectives including sustainability (Abidin, 2010; Aliagha at al., 2013;Oh et al., 2010; Samari et al., 2013). However, the exploration and discussions on these two aspects need further studies, discussions and analysis as they were studied separately while few researches discussed the challenges much more than the benefits or vice versa. Thus, this research provides another perspective in the study of GBT by considering the weightage of challenges and benefits of green building technology in terms of its implementation in the Malaysian construction industry.

In order to assist the process and delivery of this study, a research question was developed: *Are the green building technology's challenges too huge and difficult to be overcome or the benefits gained are too small and limited?*

In GBT implementation, without a well-informed picture on benefits and costs, potential stakeholders are still discouraged from entering the green building market voluntarily (Qian et al., 2015a). Therefore, this study was carried out to determine various reasons on the challenges of green building technology implementation despite the benefits of green building technology in the building construction industry. There are research progresses on the implementation of green building technology in Malaysia in terms of the barriers (Chan et al., 2016), incentives (Hashim et al., 2016), green building index (Algburi et al., 2016), global warming mitigation (Marsono et al., 2015) etc. Therefore, this study focuses on the challenges and benefits of GBT implementation in

terms of its positive and negative aspects from sustainability perspectives based on the extension of previous studies related to green building technology in Malaysia, with the enrichment of other developments of green building technology implementation worldwide.

1.3 Objectives

In order to answer the research question as presented on page 7 in Section 1.2 of this study, a few objectives are required to guide this study. The objectives of this study are:

1. To identify the common challenges encountered during the implementation of green building technology faced by the Malaysian construction industry.

2. To determine the benefits of implementing green building technology in building construction projects.

3. To measure and analyse the weightage of challenges and benefits of green building technology and how they influence the implementation of green building technology in building construction industry.

4. To evaluate the sustainability elements (economic, environmental and social factors) of implementing green building technology in building construction projects.

1.4 Scope of Work

This dissertation focuses on the challenges and benefits encountered during the implementation of green building technology in building construction projects. The study

area only involves the building construction fields such as developer companies, consultant firms, contractors, architectural firms, etc. The period of distributing the questionnaires was throughout November 2018.

The concerns of this study particularly focuses on the weightage of challenges and benefits encountered during the implementation of green building technology. In other words, this study only involves the analysis of current situations of implementing green building technology in the construction industry. In addition, the perspective of this study is from sustainability aspects.

1.5 The Importance and Benefits of the Research Project

This research project was conducted to quantify the weightage of challenges and benefits on implementing green building technology in building construction projects. Further, this study also discovers and analyses the slow progress of GBT implementation despite many benefits offered by green building technology. In other words, this study adopted a perspective to explore the balance between the challenges and the benefits of implementing green building technology in building construction projects.

It is vital to study and compare the weightage of GBT challenges and benefits simultaneously instead of identifying them separately. Thus, this study can fill the gap between the theory and the real situation of GBT implementation in the construction industry. This research can provide a better idea and picture to the construction stakeholders regarding the balance of the obstacles and benefits of implementing green building technology in building construction projects. This research may also help the construction stakeholders in understanding the positive and negative aspects of implementing green building technology. As a result, it is expected that a wiser, more

rational, more ethical and more beneficial decision can be made with the consideration of economy, environment and public in the construction industry.

1.6 Dissertation Outline

This thesis comprises five chapters. Chapter 1 is the introduction of the overall research or overview which includes relevant background and previous studies, problem statements, research question, research objectives and scopes of the study. Chapter 2 is the literature review which focuses on the relevant previous studies on challenges, benefits and current conditions of green building technology worldwide with the incorporation of sustainability elements. These aspects provide necessary information as research foundations and references for research background, methodology and analysis of the thesis. Chapter 3 is the methodology of the study describing the flows and procedures to collect data and obtain the result for the dissertation. Chapter 4 is the data analysis and data presentation which is to categorise and analyse the data collected from the questionnaire survey distributed among the building construction related companies and personnel. The data were also analysed, besides that findings and results are also discussed. Lastly, Chapter 5 is the chapter that concludes findings from this study. This research is expected to serve as a foundation to the building industry and further studies about the implementation of green building technology by quantifying the weightage between the challenges and benefits of implementation of green building technology from sustainability perspectives.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter reviews previous studies on the facts, barriers, obstacles, costs and benefits on green building projects not only in Malaysia but worldwide, including the elements of sustainability. All of these studies were essential in gaining a better understanding on GBT implementation in order to perform the process of this research in terms of the title delivery, answering the research question and attaining the research objectives. The topics discussed in this chapter include the importance of green building technology as well as the challenges and benefits in terms of economic, social, technological, environmental and governmental factors.

2.2 The Importance of Implementing Green Building Technology

The rapid development and unlimited expansion of cities, the danger of climate change, energy crisis and increasing environmental pollution may affect the future development of mankind, particularly on the aspects of human well-being. Since the 1970's oil crisis to the current 'low carbon' concept, from time to time, the whole world is becoming more aware and learning to improve the quality and standard of living despite various types of infrastructure development. As a result, the idea of green construction began to sprout throughout the world while the theory and practice of green construction and sustainable development now received a great attention from the world and even became a requirement in the industry (Jainudin et al., 2017).

In fact, according to Nejat et al. (2015), the building sector is considered as the largest energy-consuming sector worldwide, accounting for more than 40% of the global energy use and responsible for an estimated 30% of CO2 emissions. Therefore, buildings have an immense potential for global energy savings and CO2 reduction (Kimura et al., 2017). Besides, standards on building energy efficiency were only discovered when concern for rising oil prices and climate change have emerged.

Furthermore, Akimoto et al. (2015), Chau et al. (2015) and Liu et al. (2012) also stated that the building sector has the largest potential for significantly reducing greenhouse gas emissions as compared to other major emitting sectors. In addition, various studies have also confirmed that enhanced green building demand and supply could contribute to 35% reduction of carbon dioxide (CO2) emissions; 30 to 50% reduction of total energy use; 70% savings on waste output; and 40% reduction of water usage (Aliagha et al., 2013).

The building industry generally have started to aware on the benefits of "going green" but they should also be aware on various risks that are unique to sustainable design (Yang et al., 2017). This shows that the implementation of GBT requires considerations not only in terms of its risks but also other related important influencing factors.

2.3 Challenges of Implementing Green Building Technology in Building Construction Projects

As discussed in Chapter 1, the implementation of GBT in building construction projects requires considerations on many factors in order to handle various challenges

that might impede GBT implementation. The following sections present the challenges of GBT implementation, relevant to this study.

2.3.1 Economic Challenges

Generally, economic challenge refers to a condition on how to allocate scarce resources to the provision of various goods and services within the economy. In implementing GBT, economic aspect is considered as one of the challenging factors as in the construction industry, the quantification of price, costs, value, markets and uncertainties are vital in infrastructure developments. In this study, a number of economic challenges are identified and presented as follows:

2.3.1.1. Misperceptions on the Higher Costs of Green Buildings

According to the National Research Council (2011), public's perception about green buildings cost was 17% more than conventional buildings. However, the same report gathered evidence-based data for 146 green buildings showed that the actual cost was closer to 2% of total design and construction costs. Besides, over the lifetime of a green building, savings in energy use alone have far outweighed the initial 2% cost premium which results in life cycle savings which is 20% of total construction costs. The overall lack of evidence-based data to support the case of cost premium had made it difficult for the federal agency managers to make a business case for high-performance buildings.

The term green premium or green cost premium was referred to the cost premium typically needed to build a green building versus a conventional building in which the

up-front cost of green building was often greater (Dwaikat and Ali, 2016). These costs were driven by investing in high performance features such as more sustainable materials, better mechanical systems, design and modelling, as well as the cost for certification (LEED, 2016).

It is clear that green buildings have been increasingly popular in Singapore; however, despite the benefits of green buildings and various efforts being made to promote a sustainable built environment, the delivery of green buildings was still hindered by the higher cost associated with going green (Hwang et al., 2017). Many industry professionals had the perception that the design and construction costs of green buildings were 10% to 20% higher than those of traditional buildings (WorldGBC cited in Hwang et al., 2017). The results indicated that the green cost premiums of building projects only range from 5% to 10%.

2.3.1.2. Higher Initial Cost and Additional Costs of Green Buildings

From the study of Samari et al. (2013), the first (1^{st}) in term of ranking barrier in developing green buildings in Malaysia is the lacking of credit resources to cover up the front cost of building projects. It shows that from their study, among the randomly selected professionals of the Malaysian construction industry, the lacking of credit resources to cover up initial cost was the most challenging factor in the development of green buildings.

Meanwhile, in the study of Hwang et al. (2017), it is discovered that "high cost of green technologies and materials," "higher research and development costs for green building products, systems, technologies" and "lack of required green expertise and information" were the top three reasons for the cost premiums of green building projects.

In addition, Qian et al. (2015a) highlighted that in Hong Kong, special cost for using new design features and carrying out extra studies of market requirements and expectations for green buildings are considered as high risk which are regarded as major challenges in delivering green building projects. Their study also emphasised on risks aspects comprises of financial issue and time issue.

According to Zhang et al. (2012), in Hong Kong, the top barriers to the implementation of extensive green roof features were identified as increased maintenance cost and lack of incentives from governments. Meanwhile in China, an examination on ten typical barriers during the development of real estate and facilities management revealed that the high cost for green appliance and lack of motivation from customers' demand were the two distinct barriers in developing green building (Zheng et al., 2012).

Apart from higher initial cost and additional cost can also be a challenge in implementing green building technology. Hwang et al., (2015) discovered that one possible reason for the cost overrun of green building projects is that they are more likely to be delayed than traditional projects. Hwang and Leong Hwang (2013) found that 33.33% of green projects encountered a delay, as opposed to only 17.39% for traditional projects.

Harris and McCaffer (2013) reported that green construction projects would result in the increment of total project costs as relatively new technologies and systems are required to fulfil expected performances of buildings constructed. Furthermore, with the consideration of tight schedule in construction projects, project team members may not take sufficient time to understand green requirements which negatively affecting their interests in green features (Hwang and Tan, 2012). Similarly, green practices may be

costly to be implemented due to delayed constructions (Hwang and Ng, 2013). The comparatively higher initial costs and transaction costs (TCs) with their associated extra risks were the reasons to discourage potential stakeholders from entering the green building market voluntarily (Qian et al., 2015a).

TCs could be referred as the cost of organizing and marketing costs and comprised ex ante and ex post, and that the former occurred in drafting and negotiating agreements, while the latter included setup and the costs of running governance structure (Qian et al., 2015a). TCs can also be referred in terms of risk, time delay, uncertainty, and information search, setting up cost as well as learning cost during the real estate development process (REDP) of green buildings (Qian et al., 2015b).

2.3.1.3. Separated Capital and Operating Budgets in Building Construction Projects

According Eichholtz et al. (2013), separated capital and operating budgets tend to create a scenario where savings from the operation of green buildings are not used to offset any initial higher construction costs. This made the initial construction costs seems to be much higher and the benefits and savings from operational costs were not helping and reducing in the initial costs (Wang et al., 2014). Subsequently, developers or contractors tend not to agree with higher initial construction costs despite savings that can be obtained in the future (Bianchini and Hewage, 2012).

Economidou (2014) highlighted that split incentives for owner and tenant was a major reason for the separation of capital and operating budgets. Split incentives refer to a condition where the developer may not be interested in paying for green features as the benefits will be passed on the tenants (Olubunmi et al., 2016). Developer could also

charge the tenants more but the tenants have the tendency not to purchase or pay extra due to the low awareness of benefits obtained green features (Fay, 2012).

2.3.2 Social Challenges

Social challenges refer to the consideration of human-related elements due to the influence of GBT implementation. Therefore, it is concerned with GBT implementation based on what is known about human behaviour, abilities, limitations, and other characteristics. The focus of social challenges is on how people interact with GBT implementation, with GBT tools/methods and with the environment, in order to understand and evaluate these interactions.

2.3.2.1. Low Awareness of the Public and the Consumers

According to Nilashi et al. (2015), the level of general awareness about sustainable buildings and their benefits among the construction professionals was low (below moderate). Consequently, it will lead to a low level of green building implementation in terms of its concept in construction projects. In China, a research was conducted to examine typical barriers during the development of real estate and facilities management and it discovered that the lack of motivation from customers' demand was one of the two distinct barriers to developing green building (Zhang, 2015).

Meanwhile in Australia, Morrissey et al. (2013) concluded that the lack of consumer information about benefits and savings from incorporating energy-efficient devices was identified as a barrier to energy efficiency in households in Australia. In

addition, the laziness or inconveniences was the most common reason for people who do not act in a more sustainable way (Joachim et al., 2015).

O'Brien and Gunay (2014) stated that the effective operation of high-performance buildings is also dependent on the behaviour of building occupants. Occupants could easily undermine green building operations by bringing in additional appliances (e.g., heaters, fans, coffee pots), by leaving computers and lights on, and similar practices which can affect the performances of green buildings (Day and Gunderson, 2015).

2.3.2.2. Lack of Skilled Workforces

Green buildings should not only be environmentally and economically sustainable. Instead, it should also be socially sustainable. Social sustainability was connected to human factors and ergonomics (HFE) and this could help to improve the quality of green development (Thatcher and Yeow, 2016). HFE is a discipline related to the understanding of human interaction and other elements of a system in order to optimise human well-being and overall system performance (Tsau et al., 2016).

HFE can analyse, observe and understand the users' needs and expectancies in order to produce an interface which is compatible with them (Fostervold et al., 2018). If green buildings pay poor attention to the users' preferences and needs, this can cause poor energy performance during occupancy (Attaianese and Coppola, 2018).

However, most of the construction companies in Malaysia put little importance on human factors and ergonomics (HFE) due to the perception that HFE as expensive and oppressive and was not a worthwhile investment (Rozlina et al., 2012). This was also due to the plenty of replaceable cheap labour (Ismail and Yuliyusman, 2014) and

poor government regulation on labour health and safety issues (Tsau et al., 2016). According to Delmas and Pekovic (2013), industrial workers are mostly not well educated and are obliviously not well-exposed to the standard of work environmental. Moreover, poor education, training and no pressure from the top management to start HFE were the reasons that contribute to the low HFE awareness in Malaysia (Adnan and Ressang, 2016).

2.3.2.3. Changing of Conventional Method is Hard

According to USGBC (2017), the resistance to change cannot be ignored as changing is hard. People were used to work in certain way, build in certain way, using the same techniques and materials which they were familiar. Getting people to embrace change was always a challenge especially when it involves money (Bilau, 2008). As the saying goes, a leopard can't change its spots.

2.3.2.4. Lack of Education on Sustainable Development

According to Vijaya Yellamraju, LEED accredited professional, member of the United States Green Building Council (USGBC), the lacking of green education during childhood education was one of the obstacles in implementing green building technology. She also encouraged the education should include the development of technical skills such as energy simulation, day-lighting design and other sustainable designs (Bilau, 2008).

2.3.3 Technological Challenges

Technological challenges refer to the consideration of technological issue as the obstacles during the GBT implementation. Construction technologies include prefabricated construction, 3D printing, augmented reality, construction software and data ecosystem, building information modelling, cloud and mobile technology as well as research and development in materials like concrete and solar panel. The focus of technological challenges in on how is the availability and advancement of the current construction technologies in Malaysia.

2.3.3.1. Insufficient Innovative and Advanced Technologies For Green Building Constructions

According to the National Research Council (2011), the size and complexity of market for green performance technologies, limited supply and availability of green technologies, the lack of knowledge about the effects of technologies, and risk-averse behaviours of suppliers and purchasers are considered as limitations in the adoption of new technologies and tools.

According to Kimura et al. (2017), the consideration of technologies should begin with fundamental design strategies, which are based on the understanding of local climatic conditions. For instance, the green design between a winter season country and a non-winter season country was different due to the consideration of coldness in atmosphere. Therefore, the technologies applied in developed countries which most of them were winter country might not be suitable to be applied in Malaysia. Moreover, Kimura et al. (2017) also mentioned some factors to incorporate innovative and advanced

technologies, which were suitability and reliability in terms of applications, climatic conditions, durability; sustainability in terms of design lifespan and availability of technology updates; and capabilities of continuous monitoring and verification of energy performance.

2.3.3.2. The Need for Additional and Further Research in Green Building Technologies

According to National Research Council (2011), additional research was needed about processes, metrics, and evidence-based design, along with the additional testing and development of new tools and technologies. For example, the interdependencies among systems were generally unknown, which created uncertainty and reduced willingness to invest in the commercialization of promising technologies. The Federal Research and Development Agenda for Net-Zero Energy, High-Performance Green Buildings stated the followings were the fields that should be improved and researched: effective performance measures and metrics; net-zero-energy building technologies and strategies; a scientific and technical basis for significant reductions in water use and improved rainwater retention; a knowledge base and associated energy efficiency technologies and practices needed to promote occupant health, comfort, and productivity; and technology transfer. (NSTC, 2008 cited in National Research Council, 2011)

2.3.4 Environmental Challenges

Environmental challenges refer to the steps taken to reduce the negative impacts on the environment by building construction works. Environmental aspect is considered as one of the challenging factors as sustainability, integrated design, water management, waste management, energy efficiency and material efficiency are essential in minimising the environmental impacts such as air, noise, water and waste pollutions.

2.3.4.1. Sustainability of Natural Resources

In general, sustainability can be stated as the use of natural resources in such an equilibrium condition that they do not reach decay, depletion and unrenewable point and handing down the next generations by developing them (Yilmaz and Bakis, 2015).

Environmental issues as a result of current economic development models based on overconsumption of natural resources and destroying life, had downgraded the social wealth and the standards of living to the lowest level of all time. Environmental sustainability required being sensitive in the subjects of "Protection of aliveness and diversity on the earth", "Conservation of life-supports systems", "Sustainable usage of renewable resources", "Being saving in using unrenewable resources", "Minimizing harm to the environment and living things" and "Protection of cultural and historical environments" (Yilmaz and Bakis, 2015).

The same study gave an example on the sustainability of water resource. For example, main thing in water cycle was the rise of water via evaporation and then dropped again on the earth after condensation as precipitation. One of the prior conditions for continuity of this cycle was to keep the water and air clear. Thus, water pollution

caused by wastewater, agricultural pesticides and other pollution besides carbon emission negatively affected the sustainable cycle of water. In one way, environmental sustainability includes the handling of natural resources for future generations without destruction (Yilmaz and Bakis, 2015).

Sustainable architecture design plays an essential role in sustainable development. Sustainable architecture principles were ruled out under the titles of “Economy of Resources”, “Design of Life Cycle” and “Humane Design”. Moreover, energy, water, and material were basic resources which formed the main input for the construction. Protection of energy, water, and material was one of the principles of the sustainable architecture leads architecture design (Yilmaz and Bakis, 2015).

One of the key strategic goals of any sustainable construction effort must be the closing of materials loops. This meant that buildings will have to be designed for deconstruction and all products comprising the building must be able to be disassembled into their constituent materials. Therefore, the products must be reusable or the materials comprising the products must be recyclable (Kibert and Grosskopf, 2007).

The ecological systems that were integrated into a sustainable built environment strategy could provide environmental amenity as well as be a source of food. Agricultural areas could benefit from urban proximity with the flows of nutrients and water from cities benefiting farms, forests, plantations, and other systems providing food and resources for human well-being. Large scale composting where all organic waste, to include wood, paper, other organic fiber waste, and food waste from construction and demolition activities, farms, homes, restaurants, and offices were processed into nutrients for use in farming, forestry, urban landscapes and other suitable end uses (Kibert and Grosskopf, 2007). In other words, sustainable development is not the only way which care for the

construction phase but also focuses on how it can fully utilise the waste and maximise the benefits of its usage to the surrounding environment.

2.3.5 Governmental Challenges

Governmental challenges refer to the involvement and interference of government in GBT implementation. Government's policies and enforcements are essential in the decision making of GBT implementation in a building construction project. The focus of governmental challenges is on how the construction stakeholders respond to the government's approaches such as tax incentives, green rating system and voluntary implementation of GBT.

2.3.5.1. Enforcements and Incentives from Governments

Many experts believed that the role of governments in promoting green building was undeniable and effective. Rules and regulations should be replaced with enforcing new ones to support green building development (Samari et al., 2013). Sood et al., cited in Kamal and Gani (2016) also mentioned that new rules and regulations should be introduced to support green building and the enforcement of its implementation should be ensured.

The findings suggest that government roles especially incentive instruments such as structural incentives, subsidy and rebate program, tax incentive scheme, low interest mortgage loan, voluntary rating system and market and technology assistance were the significant drives for eliminating barriers to green building development (Samari et al., 2013).