CRITICAL SUCCESS FACTORS OF THE GREEN BUILDING IMPLEMENTATION IN MALAYSIAN CONSTRUCTION INDUSTRY

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ABSTRAK

Kerajaan Malaysia memperkenalkan konsep bangunan hijau bagi mencapai matlamat pembangunan mampan dalam industri pembinaan. Bangunan hijau memainkan peranan penting dalam mencapai matlamat pembangunan mampan dari segi perlindungan alam sekitar dan kesejahteraan manusia. Menurut laporan, perniagaan pembinaan mempunyai kesan alam sekitar yang paling tinggi dari semua industri, dan salah satu kaedahnya ialah menggunakan reka bentuk bangunan hijau dan menetapkan piawaian untuk mengurangkan penggunaan tenaga dalam operasi bangunan sebagai bangunan cekap tenaga. Walaupun terdapat beberapa faedah kepada masyarakat, pertumbuhan bangunan hijau terus dihalang oleh pelbagai faktor yang kelihatan menghalang pelaksanaan bangunan hijau di negara sedang membangun seperti Malaysia. Oleh itu, objektif utama kajian ini adalah untuk menentukan faktor-faktor yang mempengaruhi pelaksanaan bangunan hijau dalam industri pembinaan Malaysia. Selain daripada itu, kajian ini juga bertujuan untuk menentukan faktor kejayaan melaksanakan pelaksanaan bangunan hijau. Faktor-faktor yang mempengaruhi pelaksanaan bangunan hijau yang ditentukan berpotensi menunjukkan halangan wujud dalam industri pembinaan dalam mengaplikasikan konsep bangunan hijau manakala faktor kejayaan yang dianalisis dapat mewujudkan kesedaran di kalangan kontraktor untuk meningkatkan pelaksanaan bangunan hijau di bangunan akan datang. Daripada keputusan yang diperolehi, faktor sosial dianggap sebagai faktor utama yang mempengaruhi pelaksanaan bangunan hijau diikuti oleh faktor perbandaran. Faktor kejayaan kritikal penggunaan bangunan hijau di Malaysia yang diperolehi adalah kecekapan alat penarafan bangunan hijau yang menggalakkan bangunan mampan, bangunan kerajaan dan latihan dan program pendidikan tinggi mengenai bangunan hijau.

ABSTRACT

The government of Malaysia introduced the concept of green building in order to achieve sustainable development goals in the construction industry. Green building plays an essential part in accomplishing the goal of sustainable development in terms of environmental protection and human well-being. According to reports, the construction business has the highest environmental impact of all industries, and one of the methods is to use green building designs and set standards to reduce energy consumption in building operations as energy efficient buildings. Green building has become more popular and significant in Malaysia, although it still does not appeal to all segments of the construction sector. While there are several benefits to society, the growth of green building continues to be hampered by various factors that appear to be impeding the implementation of green building in emerging nations such as Malaysia. Therefore, the main objective of this study to determine the factors affecting the green building implementations in Malaysian construction industry. Other than that, this study also aims to determine the success factors implementing the green building implementation. Factors affecting the implementation of green building determined have the potential to show barriers exists in the construction industry in applying green building concept while success factors analysed can create awareness among the contractors to increase the green building implementation in future buildings. From the results obtained, the social factor was perceived to be the major factor that impacts the green building implementation followed by municipal factor. The critical success factors of green building adoption in Malaysia obtained are the efficiency of green building rating tool which promotes sustainable buildings, government set an example by implementing green building concept in government buildings and trainings and higher education programme on green buildings.

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LIST OF ABBREVIATIONS

GHG	Global Greenhouse Gas
SDG	Sustainable Development Goals
WGBC	World Green Building Council
GBI	Green Building Index
CSF	Critical Success Factor
USGBC	United States Green Building Council
GBCI	Green Building Council of Indonesia
PAM	Pertubuhan Arkitek Malaysia

CHAPTER 1

INTRODUCTION

1.0 Background Study

Over the years, modern building practices has been showing less attention towards energy efficiency, environmental and social impacts throughout the life cycle of the building. Due to careless use of the natural resources, the environment is put under pressure. About 40% of the world's resource and energy used is linked to the construction and maintenance of buildings (IEA, 2019). A building is product of a multi-stage process which includes planning, designing, operating, maintenance and demolishing. Each of these processes has its significant effects towards the environment where it contributes to the one-third of global greenhouse gas (GHG) emission. Greenhouse gas emission have a wide range of environmental and health consequences. They contribute to respiratory problem caused by smog and air pollution, as well as contributing to climate change by trapping heat. Other implications of climate change produced by greenhouse gases include extreme weather, food supply shortages and increasing wildfires (Nunez, C., 2021). Moreover, the amount of construction materials wasted on the site is relatively high and equals 9% by weight of the purchased materials as identified in investigation of material waste generated in a Dutch construction project based on a study conducted by Forsberg & Saukkoriipi (2007).

Green building is an outcome of a design which focuses on increasing the efficiency of resource used comprising 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 & Browning, 2005). Green building theory is also a continuous improvement in the construction process where the workers have to constantly learn and be updated with new ideas to keep up with the Sustainable Development Goals (SDG). According to World Green Building Council (WGBC), out of 17 SDG by the United Nations General Assembly, 9 goals have been related to green building. Starting with Goal 3 (Good health and well-being), Goal 7 (Affordable and clean energy), Goal 8 (Decent work and Economic growth), Goal 9 (Industry, innovation and infrastructure), Goal 11 (Sustainable cities and communities), Goal 12 (Responsible consumption and production), Goal 13 (Climate action), Goal 15 (Life on land) and Goal 17 (Partnership for the goals).

According to the Malaysian Construction Industry Master Plan (2005–2015), sustainability and green building are important issues for the Malaysian construction industry. If nothing is implemented to change energy efficiency in the Malaysian building sector, which consumed approximately 8,000 GWh of energy in 2008, the sector will continue to contribute considerably to greenhouse gas emissions (Sood et al., 2011). Malaysia's government is equally determined to overcome challenges of sustainability. Therefore, in March 2007, the Malaysian government announced the Green Building Mission to raise awareness, encourage, and consolidate efforts toward attaining sustainable building. Later in 2009, Green Building Index (GBI) was introduced to measure, rate and certify ‘greenness’ in building. Commercial, residential, hotel, and resort properties, which are separated into new and old buildings, each have their own rating system. In Malaysia, there are over 500 property projects approved by the GBI as of June 2019 (Jacqueline, 2020).

1.2 Problem Statement

The Malaysian government has invested heavily in the construction industry. According to the Department of Statistics Malaysia (2019), construction output increased by 7.2 percent in 2017 when compared to 2015. Due to the rapid development of the construction industry, demand of houses and major infrastructure projects contributes to the increase of construction waste which is a result of site clearance or demolition waste (Wong and Alia, 2019). Additionally, the country was ranked number 28 among other countries in Carbon Dioxide (CO_2) Emissions at 7.2 Metric Tons Per Capita in 2019 (NationMaster, n.d). 24% from the total CO_2 comes from the construction industry in the country (Samad et al., 2008). There are therefore two categories of carbon emissions in the construction industry: direct emission and indirect emission. Direct carbon emissions come from on-site construction activities like building, maintaining, or demolishing; indirect carbon emissions come from operations like brick manufacturing upstream that supply construction activities with both materials and services (Lu et al, 2016). Khozema et al (2020) stated that carbon emissions play a substantial role in global warming and climate change, which can have serious negative impacts on both people and the environment. In order to reduce the impacts, the green building concept is the key solution for it specially to reduce carbon emission which results from construction sector.

The implementation of green building in the Malaysian construction industry may serve as a catalyst for green benchmarking but adoption of green building into projects has been a challenging issue for all the parties. Even though green buildings are highly beneficial, the implementation of it in Malaysian construction industry is

voluntary instead of compulsory (Fatin et al, 2022). What has been stopping their wider adoption in Malaysia? There is very limited of research into the difficulties and success factors that contribute to green building implementation. The majority of research and papers focus on reducing greenhouse gas emissions through green building, energy conservation, green procurement, and other methods. As the concept is new, it has caused a lot of confusion and concerns among potential buyers as well as construction industry professionals like developers, architects, engineers, town planners, and contractors (Ezanee and Chong, 2015).

This study focuses on building project stakeholders' perspective on implementing green building in Malaysia. This research aims to identify the contractors' perspective on factors affecting the implementation of green building in Malaysia, also to determine the critical success factors (CSF) of the implementation of green building in Malaysia. In general, the phrase "critical success factors" refers to a limited set of elements that, when combined, will guarantee competitive performance success for an individual, a group, or an organisation (Alazmi and Zairi, 2003). If these elements are not given enough attention, the organization's efforts will provide less than optimum results (Hassan and Mahdavi, 2016). Hence, in this research the highest critical success factors derived from the data can be used to increase the implementation of green building in Malaysia.

1.3 Research Objectives

The following are research objectives for the study on critical success factors (CSF) of Green Building Implementation in Malaysian Construction Industry:

1. To identify the different types green buildings practices for construction project
2. To determine the factors that affecting the implementation of green building.
3. To analyse the critical success factors for the implementation of green building in Malaysian construction industry.

1.4 Scope of study

This report mainly investigates the critical success factors of Green Building implementation in Malaysian Construction Industry. To begin with, factors affecting the green building implementation in Malaysian Construction Industry was assessed and calculated in terms of financial, technological, social and municipal. Next, the success factors of green building implementation in Malaysian Construction Industry were assessed and calculated. Finally, both the factors are analysed and ranked. This study was conducted using a questionnaire survey to gather information about the views and perceptions of building projects stakeholders especially contractors. Moreover, an additional study is carried out on green building practices around the world and in Malaysia which focuses in residential buildings through literature review to support the whole report.

1.5 Final Year Project Outline

The thesis is divided into five chapters and the contents for each chapter in this study are as following:

Chapter 1: This chapter covers the overview and background of this research. It gives a brief introduction about the green building and its relation to the sustainability. This chapter also describes the problem statement, research objective, and scope of study.

Chapter 2: This chapter discusses the literature review on what is green building and its practices in Malaysia and around the world. Moreover, this chapter also provides explanations for factors affecting the green building implementation in Malaysian construction industry. Plus, this chapter discusses about the success factors of green building implementation in Malaysian Construction Industry.

Chapter 3: This chapter covers the methodology used to conduct this study. This chapter explains briefly about the questionnaire survey that was used to conduct this research and the content of the questionnaire.

Chapter 4: This chapter covers the outcome of the results and discussion part of this research. The experiment results obtained are elaborated further and analysed.

Chapter 5: This chapter covers the conclusion achieved from the observation and recommendations for the improvisation of this study in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Green Building vs Sustainability

2.1.1 Definition of Green Building

The word "green building" has recently become popular, along with a slew of other related terms. Academicians, professionals, and organisations from all over the world have many definitions for green building. According to the United States Green Building Council, green building design and construction aims to "substantially minimise or eliminate the negative impact of the built environment." the impact of buildings on the environment and the people who live in them (Nora Knox, 2015).

According to a study by Chatterjee (2009), "green building practise" is a method of designing buildings and infrastructure that uses fewer resources, has fewer negative effects on the environment, and provides better living conditions for people. Green buildings are high-performing in terms of the environment, economy, and engineering. Energy efficiency and conservation, better indoor air quality, resource and material efficiency, and occupant health and productivity are just a few of them.

Green building is the process of increasing a building's efficiency by conserving water, energy, and materials while simultaneously reducing the building's impact on human health and the environment. It also entails striking a balance between construction development and environmental sustainability. (Akadiri and Olomolaiye, 2012).

Green buildings, which are frequently characterised as those with natural ventilation capabilities, i.e., low-energy or self-running structures, are presently at the forefront of building research and climate change mitigation scenarios. (Deuble and de Dear, 2012).

Several critical fundamentals of green building definition were underlined in the literature. Building lifecycle perspectives, human health challenges, and mitigating building impacts on the environment, economy, and society are the fundamentals. A full definition of green building can be derived from the evaluated material from relevant publications as follows "Green building reduces the negative impact on human health, environment, economy and society during the building lifecycle. Green building overall process starting from the planning, design, construction, operation and maintenance needs to reduce the overall impacts on its surrounding (human health, environment, economy and society) (Musa et al, 2016).

2.1.2 Sustainability and Green Building

Buildings are a major source of carbon emissions, owing to their use of fossil fuels throughout operations. In fact, cities and urban areas are responsible for approximately 75 percent of carbon emissions. If these buildings continue to be developed and run in the traditional manner, only environmental damage will progress (Laken J., 2017). Green building projects can help to attain construction sustainability. As the term 'sustainability' and 'green' is being used widely, there is a slight difference between these two terms. A widely cited sustainability definition is "development that meets the needs of the present without compromising the ability of

future generations to meet their own needs" (World Commission on Environment and Development, 1987). The primary distinction between green and sustainable is that "green" is concerned only with one component, environmental health, but sustainability is concerned with the entire system, including economic, social, and environmental advantages (Misachi, 2021).

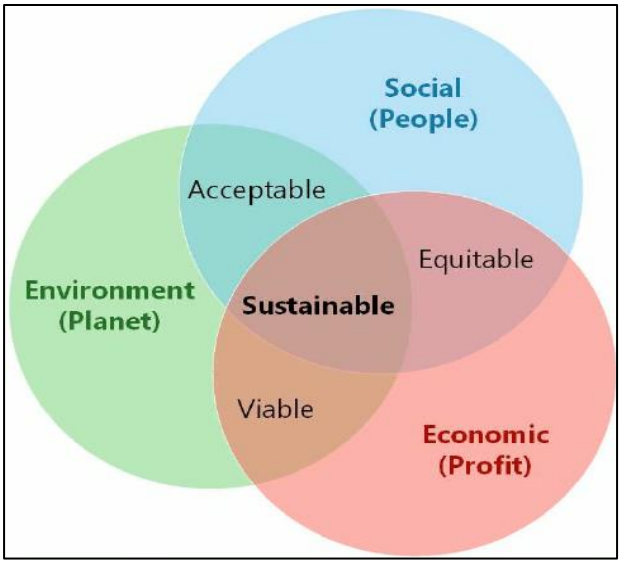

Figure 2. 1: Three pillars of Sustainability (Source: Based on 'sustainable development' from Wikimedia.org)

Green, on the other hand, is an environmental concept that refers to the individual activities and processes that make up the gradual steps toward environmental sustainability (IotaComm., 2021). This means that a green building could not have been constructed sustainably, and a sustainable building could not function without green activities.

Table 2. 1: Differences between Green and Sustainability (Source: Yanarella et al.,2009)

Dimensions	Green	Sustainable
Relation to sustainability tripod	Only one leg (environmental improvement)	All three legs (environment health, economy vitality, social justice)
Focus	Individual components	Interplay of individual components and whole system
Tactics/strategy	Tactical application of activities that involve "picking low-hanging fruit"; promoting individual changes and reforms to make world less unsustainable	Strategic discovery of the proper scale that will make successive policy steps and actions easier and less costly by designing and implementing a sustainable, self-balancing system
Political orientation	Conventional, "pragmatic realist," reformist	Innovative, visionary, revolutionary ("going to the roots")
Scale	Individual devices, products, indicators, practices, buildings as most tractable level for greening	City region as the level at which human and social disequilibriums and ecological insults can be dynamically rebalanced
Risks or excesses	Greenwashing	Utopian fantasizing or top-down authoritarian policy action
Definition of success	Infinite progress of incremental improvements	Reduction of ecological footprint to a city region's fair Earth-share

The goal of sustainability in construction is to minimise or eliminate a building's negative effects over its full lifespan while maximising its economic viability and human comfort and safety. Hence, the future of green building practices will not be determined by a single product, practise, or technology. Rather, it will be determined by how these three factors interact to develop initiatives that consider the building's overall health, as well as the health of its residents and the environment. (Keiner, 2010). In order to satisfy sustainability in constructions, for contractors to build, developers must design and construct sustainable buildings that can deliver energy, water savings, and a healthier indoor environment. This might be the beginning of a new era in which developers and contractors must be more creative, imaginative, and determined to move away from traditional building and into a more

beneficial but still profitable project with their own style and management (Awang et al., 2016).

2.2 Green Building Practices Around the World

According to World Green Building Council, green building practices includes efficient use of energy, use of renewable energy, pollution and waste reduction measures, good indoor environmental air quality, use of materials that are non- toxic, and consideration of the environment in design, construction and operation. Green building practices is measured through a rating system in many countries that implement green building concept in the infrastructures. Building rating systems are used all around the world to evaluate and score a building's environmental performance by granting "credits" for different categories. Other than that, green building codes which contains requirements are generally applied to the design and construction of a building in some countries. In this section, green building rating system for residential infrastructures around the world are highlighted.

2.2.1 Green Building Practices in Indonesia

Indonesia was primarily involved in the implementation of green building concepts through the public and commercial sectors, groups, and academic institutions. In practise, Indonesia concentrates on both new and old structures. The implementation of green construction principles has yielded some benefits in terms of cheaper operating costs, reduced energy consumption, and reduced waste. The Green Building Council of Indonesia (GBCI) has goals of promoting the implementation of

green building principles in all building sectors in their country, and one of their efforts is to design a rating system for structures to meet a green standard called "Greenship.". In this rating system, there are two types of criteria. The first are prerequisite criteria, and the second are assessment criteria. Each category has necessary criteria that must be met before further evaluation. Each category has its own set of assessment criteria, and the completion of these criteria must be tailored to the building's capabilities (GBCI, 2010).

There are two Greenship rating tool which can be used to for residential infrastructures which are GREENSHIP Neighborhood and GREENSHIP Homes. GREENSHIP Neighbourhood is a certification system that aims to create a sustainable and environmentally friendly space for its users, going beyond the scale of buildings and taking into account the interaction between buildings, nature and people. GREENSHIP Neighborhood can be used to assess residential neighbourhoods, central business districts and commercial areas, on a small or large scale. The GREENSHIP neighbourhood certification consists of two (2) types dedicated to the proposed project and existing projects. For the planned project, the project team will have the opportunity to receive an award for the project in the final design and planning phase based on the GREENSHIP assessment scheme.

This type of certification is for areas that are still in the planning stage. Besides, for projects that have been implemented and / or already operational. The technology is carefully studied in terms of design, construction and operation; to determine the overall performance of the region. The GREENSHIP Neighborhood Assessment System consists of Eligibility provisions and 7 Assessment Categories which are Land

Ecological Enhancement (LEE), Movement and Connectivity (MAC), Water Management and Conservation (WMC), Solid Waste and Material (SWM), Community Wellbeing Strategy (CWS), Building and Energy (BAE) and Innovation and Future Development (IFD). The GREENSHIP Neighborhood certification system has a maximum of 124 points (GBC Indonesia, n.d).

Table 2. 2: Scoring for each category in GREENSHIP Neighborhood (Greenship neighborhood version 1 - GBC Indonesia, n.d)

Category	Score	Weightage (%)
LEE	19	15
MAC	26	21
WMC	18	15
SWM	16	13
CWS	16	13
BAE	18	15
IFD	11	9
Maximum Score	124	

On the other hand, GREENSHIP Homes assess many types of houses includes single residential house built attached to the ground, new houses, existing houses, and redevelopment houses. The GREENSHIP Homes assessment system consists of Eligibility provisions and 6 assessment categories which are Appropriate Site Development (ASD), Energy Efficiency and Conservation (EEC), Water Conservation (WAC), Material Resources and Cycle (MRC), Indoor Health and Comfort (IHC) and Building and Environmental Management (BEM). Each category consists of several criteria containing Prerequisite, Credit Point, and Bonus Point. The

GREENSHIP Homes assessment system has a maximum of 77 points (Greenship Rating Tools Homes, n.d)

Table 2. 3: Number of Criteria and Benchmarks in each Category (Greenship Homes Version 1 - GBC Indonesia, n.d)

Category	Total Criteria			Total Score	
	Prerequisite	Credit	Bonus	Credit	Bonus
ASD	2	6	-	-	-
EEC	2	5	1	15	2
WAC	-	5	-	13	-
MRC	1	8	-	11	-
IHC	1	6	-	13	-
BEM	01	7	1	11	2
Number of criteria and benchmark	7	38	2	77	4

Table 2. 4: Greenship Scoring and Rating Award (Greenship Homes Version 1 - GBC Indonesia, n.d)

Rating Award	Percentage (%)	Minimum Score
Platinum	73	56
Gold	57	43
Silver	46	35
Certified	35	26

2.2.2 Green Building Practices in United States of America (U.S.A)

In terms of codes, the 2018 International Green Construction Code (IgCC) is the single most effective method for the design and construction industry to provide sustainable, resilient, and high-performance buildings. These codes are designed to be mandatory and must be included into a jurisdiction's laws and ordinances, as well as to serve as a supplement to other International Code Council model codes. IgCC is intended to work in tandem with the International Code Council's family of codes and to supplement voluntary green building rating systems (Environmental Protection Agency n,d.).

Other than that, LEED is a systematic and thoroughly quantified approach to all sorts of buildings. LEED is becoming the standard by which many green buildings are measured because it has accomplished so much and is so widely accepted (Bahaudin et al., 2014). LEED certification applies to the design, construction, and operation of all types of structures in a voluntary option (Environmental Protection Agency n,d). The U.S. Green Building Council administers LEED, which has a far broader "triple bottom line" approach that considers people, environment, and

business, rather than just energy use. The triple bottom line considers the economic, environmental, and social challenges that arise throughout the entire construction process, from concept to design to construction and operation. (Bahaudin et al, 2014). Projects that go through a process of verification and evaluation by GBCI and are awarded points that correspond to a LEED certification level: certified (40-49 points), silver (50-59 points), gold (60-79 points) and platinum (80+ points) (U.S. Green Building Council, n.d).

LEED certified homes are designed to provide clean indoor air and ample natural light and to use safe building materials to ensure comfort and good health. They help by reducing energy and water consumption by reducing the energy bills each month, among other financial benefits (LEED certification for residential, n.d). According to LEED Rating System, LEED homes are used for single family homes, low-rise multi-family (one to three stories) or mid-rise multi-family (four or more).

Figure 2. 2: Highest possible score in LEED Homes. (Source: LEED for homes, RND Construction)

LEED for Neighborhood Development (LEED ND) is designed to inspire and help create better, more sustainable and well-connected neighbourhoods. It can be used for new land development projects or redevelopment projects with residential, non-residential or mixed use. Projects can be at any stage of the development process, from conceptual planning to construction (LEED certification for Neighborhood Development, n.d). LEED ND strategies can be applied to community issues such as balancing employment and housing, affordable housing, and universal visit ability. (LEED v4: Neighborhood Development Guide).

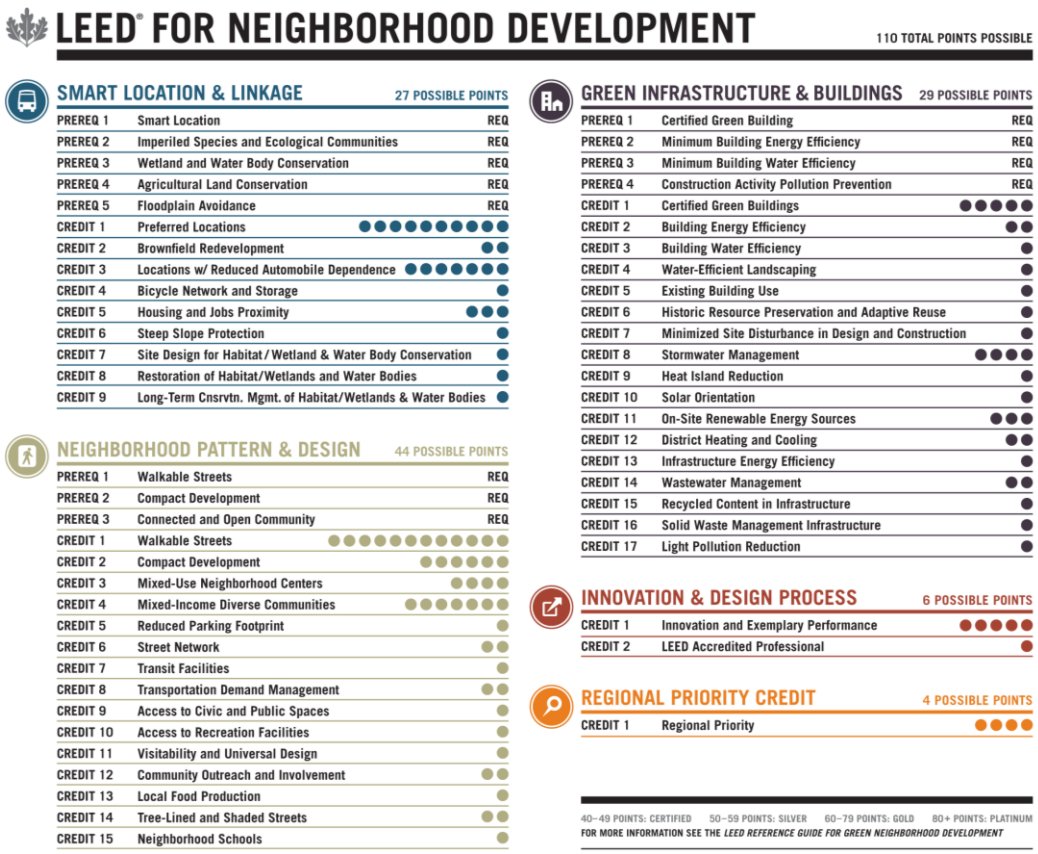

Figure 2. 3: LEED ND rating system (Source: US Green Building Council)

2.2.3 Green Building Practices in Singapore

The Building and Construction Authority of Singapore launched its Green Mark rating system in 2005 which is a green building rating system for evaluating a building's environmental impact and performance. It provides a comprehensive framework for assessing the overall environmental performance of new and existing buildings to promote sustainable design and best practices in building construction and operation (Green mark certification scheme, n.d). The scoreboard includes a comprehensive scoring system and verification process to determine how green the building or project is. The total number of points obtained is an indication of the environmental compatibility of the design and operation of the building. Depending on the overall assessment and the score obtained, the building will be certified to have met the respective Green Mark score (Green mark assessment criteria and online application, n.d). A decade later, according to a report in World Green Building Trends, 89% of Singapore's design and construction companies said they expect green construction projects exceed 60% of the work they have done (Cubick R. ,2018).

The Green Mark System has also developed several systems for different types of application spaces, although the Green Marking for Non-Residential and Existing Non-Residential is still the most used (Cubick R. ,2018). As we are focusing in residential system, Green Mark for Residential Buildings GM RB: 2016 is the fifth edition of the Green Mark scheme for new residential buildings. To align the criteria with the sustainable results of Green Mark RB: 2016, the criteria have been restructured into 5 sections, with 16 criteria and 48 sustainability indicators. The total points are 140 points, including 20 points from Section 5: Advanced Green Efforts (GM RB: 2016 - building and construction authority (BCA), n.d). The 5 sections

include Climatic Responsive Design, Building Energy Performance, Advanced Green Efforts, Resource Stewardship and Smart and Healthy Building. Moreover, Super Low Energy Programme (SLE) which the next wave of green building movement in Singapore also can be applied to residential buildings. SLE buildings feature best-in-class energy efficiency, use of onsite and offsite renewable energy, and other smart energy management strategies (Super Low Energy Programme. BCA Corp., n.d).

Table 2. 5: Green Mark Award Rating score for New Residential Building (Source: GM RB: 2016 - building and construction authority (BCA))

Green Mark Rating	Green Mark Score
Green Mark Platinum	70 and above
Green Mark Gold^{PLUS}	60 to <70
Green Mark Gold	>50 to <60

Table 2. 6: Green Mark Award Rating score for Existing Residential Building (Source: BCA Green Mark for Existing Residential Buildings Version ERB 1.1)

Green Mark Points	Green Mark Rating
90 and above	Green Mark Platinum
85 to <90	Green Mark Gold^{Plus}
75 to <85	Green Mark Gold
50 to <75	Green Mark Certified

2.3 Green Building Practices in Malaysia

Architects at PAM have been designing and working toward a more sustainable and green architecture for many years. In 2008, the necessity for a localised Green Building rating tool became more apparent, particularly in light of growing demand from building end-users for Green certified buildings that did not contribute excessively and negatively to environmental degradation (Ar Dr Tan Loke Mun, 2009). Malaysia developed the Green Building Index (GBI) in 2009, which is the country's green assessment instrument for towns and structures. GBI was founded to promote environmental sustainability and improve awareness among developers, architects, engineers, planners, designers, contractors, and the general public. Green building assessment tools can be applied to all types of buildings, however, the GBI has the privilege of being widely used in practice for many buildings, unlike others which are considered newly developed (Foo, 2018). There are six main criteria for buildings to earn GBI certification which are Energy Efficiency, Indoor Environmental Quality, Sustainable Site Planning and Management, Materials and Resources, Water Efficiency, and Innovation. According to GBI Design Reference Guide - Residential New Construction (RNC), this assessment system for residential buildings has a maximum point of 100.

Table 2. 7: Assessment Criteria and Overall Points Score (Source: GBI Design Reference Guide - Residential New Construction (RNC))

PART	ITEM	MAXIMUM POINTS
1	Energy Efficiency	23
2	Indoor Environmental Quality	11
3	Sustainable Site Planning & Management	39
4	Material & Resources	9
5	Water Efficiency	12
6	Innovation	6
	TOTAL SCORE	100

Table 2. 8: Green Building Index Classification (Source: GBI Design Reference Guide - Residential New Construction (RNC))

POINTS	GBI RATING
86 to 100 points	Platinum
76 to 85 points	Gold
66 to 75 points	Silver
50 to 65 points	Certified

Apart from GBI, other sustainability assessment tools have been developed to measure the sustainability of construction projects which can be applied to residential buildings are Green Real Estate (GreenRE) and Green Performance Assessment System (Green PASS). The GreenRE assessment scheme was established in 2013 by Real estate and Housing Developments' Association (REDHA) and it is a recognized green building classification system adapted to the tropical climate. GreenRE sets parameters and establish indicators to control the design, construction and operation of buildings towards greater energy efficiency and improvement environmental performance (Residential Building & landed home – GreenRE, n.d). According to the Design Reference Guide for Residential Buildings and Landed Homes, the type of buildings that can be assessed are landed homes such as residential bungalows, villas, terrace houses and multi-storey residential such as residential flats or condominiums. The GreenRE rating system is divided into six sections including Energy Efficiency, Water Efficiency, Environmental Protection, Indoor Environmental Quality, Other Green Features and Carbon Emission of Development. The maximum achievable GreenRE score for a project is capped at 100 credits and this does not include the 15 bonus points available at Energy Related Requirements when a project uses renewable energy sources (Residential Building & landed home – GreenRE, n.d).

Table 2. 9: GreenRE Residential Building Rating System Scoring (Source: Residential Building & landed home – GreenRE, n.d).

Score	Rating
90 and above	GreenRE Platinum
85 to < 90	GreenRE Gold
75 to < 85	GreenRE Silver
50 to < 75	GreenRE Bronze

On the other hand, Green Performance Assessment System (Green PASS) also can be used to assess residential buildings as it can be used to any type of new and existing buildings (CIDB, 2018). The Green Performance Assessment System in Construction (Green PASS) is developed to meet this need through compliance with standards that promote sustainable construction in an integrated manner with other Construction Industry Standards (CIS). The evaluation of Green PASS is divided into two categories which are Building Construction and Building Operation where both will be evaluated for embodied carbon and operational carbon (Green Performance Assessment System in Construction, 2018). Embodied carbon is referred to as COe_2 emitted during construction or customization processes. Operational carbon is the CO_2 emitted during the operational phase of the building until the end of the building's lifespan. This assessment system estimates carbon emissions from construction to operation over the entire life cycle of the building for 50 years (CIDB, 2018). It applies to new and existing buildings and includes five elements which are site, energy, indoor environmental quality, water and waste. Achieving 100% CO_2 reduction is called neutral CO_2, represented by six diamonds (Green Performance Assessment System in Construction, 2018).

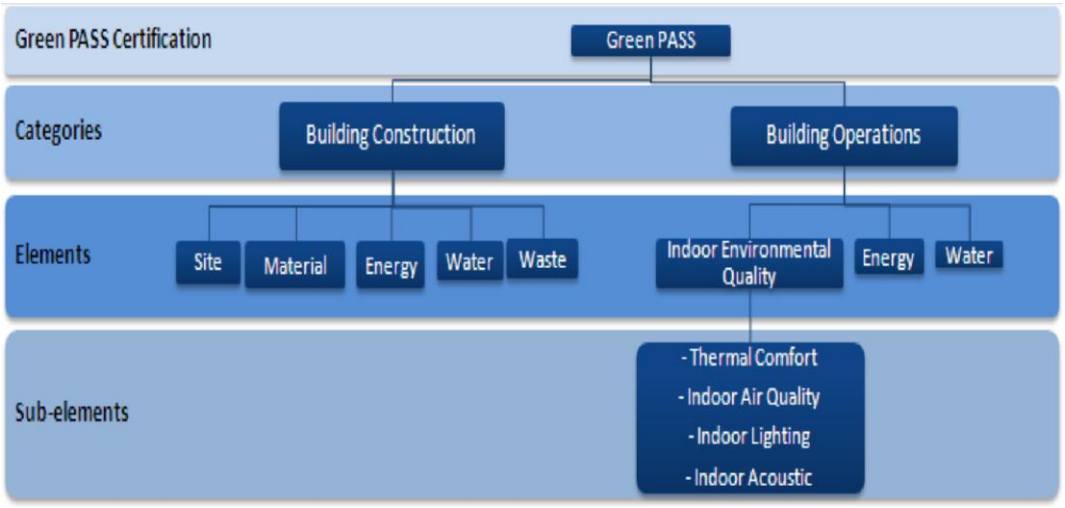

Figure 2. 4: The overall structure of the Green PASS (Source: Green Performance Assessment System in Construction, 2018)

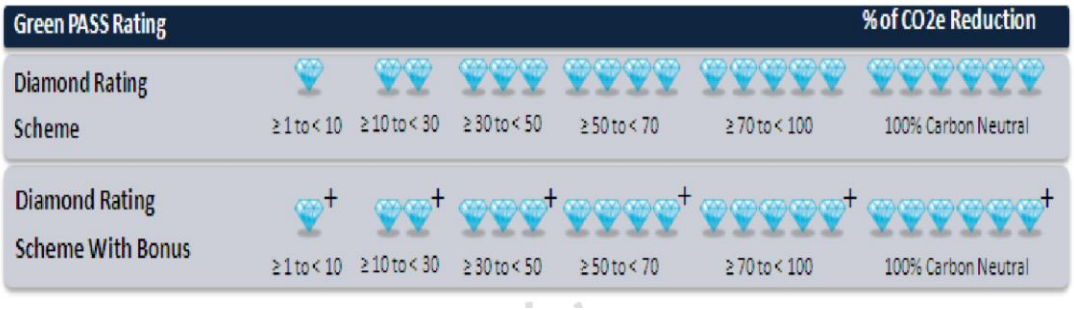

Figure 2. 5: Green PASS Diamond Rating According to Percentage of $C0_2$ Reduction (Source: Green Performance Assessment System in Construction, 2018).